Nutritional management of children with CKD

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Pathophysiology of growth failure in CKD

- Malnutrition
- Catabolism
- Inflammation
- Metabolic acidosis
- Renal anemia
- Genetics (syndromes)
- Primary renal disease
- IUGR, parental ht
- Hormonal disturbances
  - GH- / IGF1- insensitivity
  - Hypergonadotropic hypogonadism (hypothyroidism)
  - Glucocorticoid treatment
- Renal losses (H₂O & E’lytes)
- Renal osteodystrophy

Outline

- Why bother?
- Enteral feeding
- Gastrostomy insertion
- What the guidelines recommend
- Case study
Why focus on nutrition?

“The dialysis is easy, it’s the feeding that is difficult”

Alan Watson, 2006

- Energy cost of growth 35% at 1 m, 3% at 12 m and 4% at puberty. Growth velocity sensitive indicator of energy status (Butte et al 2000)

- Serum albumin is a strong predictor of clinical outcome in children on dialysis (Wong et al 2002)

- Short stature at start of dialysis is a marker for poor outcome (Furth et al 2002)

Phases of growth

% final height achieved at the end of each phase of growth

Calories per day incorporated into new tissue

Growth pattern and dietary intake in children with CKD

>80% DRI → normal growth

<80% DRI → reduced growth velocity

<40% DRI → cessation of growth

Betts and Magath; BMJ 1974
Causes of poor nutritional intake

In CKD:
- Appetite:
  - Altered taste sensation
  - Multiple medications
  - Polyuria
  - Hormonal regulation of appetite and satiety
- Vomiting:
  - Gastro-oesophageal reflux
  - Abnormal gastrointestinal motility due to elevated polypeptide hormones
- Disturbed feeding history
- Co-morbidities

On dialysis:
- Fluid restriction
- Dialysate losses
- Peritoneal dialysis
- Full abdomen and constipation

Altered gastrointestinal motility and appetite control

Polypeptide hormones
- Cholecystokinin - delays gastric emptying / satiety
- Gastrin - initiates post prandial motor activity

Ravelli AM Arch Dis Child 1992

Cytokines
- Leptin - regulator of food intake & energy homeostasis
  Increase levels in CRF / reduce appetite / increase metabolic rate
- Ghrelin - appetite regulator

Mak RH et al KI 2012

IPPN Infant Growth and Nutrition Study

153 children <2 years

- 41% of the patients were enterally fed
- Gastrostomy feeding was almost exclusively in the US and Europe

IPPN data
The advantages of gastrostomy feeding

- Improvement in vomiting, appetite, nutrition and growth
- No interference with oromotor skills
- Ease of administration of medications (and fluids post transplant)
- Hidden under clothes

% time with gastrostomy feeding was an important predictor of longitudinal growth

<table>
<thead>
<tr>
<th>Final assessment</th>
<th>Demand</th>
<th>NG</th>
<th>Gastrostomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ht SDS</td>
<td>-2.7</td>
<td>-2.9</td>
<td>-1.7</td>
</tr>
</tbody>
</table>

International Pediatric Peritoneal Dialysis Network, JASN 2011
Gastrostomy placement techniques

- **Open (Stamm) procedure**
- **Percutaneous**

**Blind procedures**
- Surgical team
  - Endoscopy +/- laparoscopy (PEG)
- Interventional radiology
  - Antegrade fluoroscopically guided
  - Retrograde placement

High risk of gastric contents spilling into peritoneum

Timing of gastrostomy insertion in the child on PD

- Before PD catheter insertion
- At the same time as a PD catheter insertion
- After commencing PD

High risk if endoscopic insertion of gastrostomy in a child on PD

<table>
<thead>
<tr>
<th>Authors, year of publication</th>
<th>Peritonitis</th>
<th>PD catheter replacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schroakenburg et al, 2006</td>
<td>PEG</td>
<td>PEG – 8/27</td>
</tr>
<tr>
<td></td>
<td>Peritonitis – 10/27 (37%)</td>
<td>- 4 transferred to HD</td>
</tr>
<tr>
<td></td>
<td>Fungal</td>
<td>- 2 deaths</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ledermann et al, 2002</td>
<td>Open</td>
<td>PEG - in 4/5 pts (1-5 days post-op)</td>
</tr>
<tr>
<td></td>
<td>– 1 fungal peritonitis</td>
<td>- 1 transfer to HD</td>
</tr>
<tr>
<td></td>
<td>PEG</td>
<td>Open– 4/9 (1 related to g-tube)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PEG - PD cath removed in 3/5 pts</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 3 transfer to HD</td>
</tr>
<tr>
<td>Ramage et al, 1999</td>
<td>Pre G-tube</td>
<td>Pre G-tube – 0</td>
</tr>
<tr>
<td></td>
<td>– 6 per pt-mt</td>
<td>Post G-tube - 12</td>
</tr>
<tr>
<td></td>
<td>Post G-tube – 8 per pt-mt</td>
<td></td>
</tr>
</tbody>
</table>
K/DOQI 2008 Guidelines

- Ideally, placement of a g-tube should occur before PD catheter placement.
- The placement of a PEG while on PD is discouraged.
- An open gastrostomy, can be performed safely in children on PD therapy with suitable precautions.
- No evidence of an increased incidence of bacterial or fungal peritonitis with an established gastrostomy.
- Higher risk of infections after PEG insertion in malnourished children.

Case based discussions

Case

- Male infant with PUHs and dysplastic kidneys.
- Born at 38 weeks, birth weight of 2.1 kg, length 45 cm and head circumference 31 cm (all 2nd centile).
  No respiratory support needed.
- The baby was catheterised at birth and passed 2-3 ml/kg/hour of urine.
Options: Would you

- Keep nil by mouth
- Withhold milk feeds and start clear fluids
- Start a low electrolyte feed if the mother does not want to breast feed
- Encourage breast feeding if that is what the mother wants to do
- Start a normal baby formula if the mother does not want to breast feed

Options: Would you

- Keep nil by mouth
- Withhold milk feeds and start clear fluids
- Start a low electrolyte feed if the mother does not want to breast feed
- **Encourage breast feeding if that is what the mother wants to do**
- Start a normal baby formula if the mother does not want to breast feed

Case

- Support the mother in breast feeding or use a standard whey based infant formula
- The baby will need 2 to 3 hourly feeds in order to take adequate nutrition to maintain growth
- If the intake from breast feeding alone is inadequate (static weight) offer a standard infant formula by bottle as a supplementary feed

<table>
<thead>
<tr>
<th>Age</th>
<th>Energy (kcal/kg)</th>
<th>Protein (g/kg)</th>
<th>Feed volume (ml/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-2 months</td>
<td>96-120</td>
<td>2.1</td>
<td>150-180</td>
</tr>
</tbody>
</table>
Energy requirements - KDOQI

100% Estimated Energy Requirements for chronological age
Individually adjust for physical activity level & body size
Adjust energy intake based upon the response in rate of weight gain or loss

<table>
<thead>
<tr>
<th>Age</th>
<th>EAR (calories)</th>
<th>EER (calories)</th>
<th>EAR v. CRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;6 months</td>
<td>556</td>
<td>550</td>
<td>1</td>
</tr>
<tr>
<td>7-12 months</td>
<td>682</td>
<td>710</td>
<td>1</td>
</tr>
<tr>
<td>1-2 years</td>
<td>855</td>
<td>1018</td>
<td>1</td>
</tr>
<tr>
<td>3-9 years</td>
<td>1448</td>
<td>1892</td>
<td>1</td>
</tr>
<tr>
<td>10-11 years</td>
<td>2097</td>
<td>2179</td>
<td>1</td>
</tr>
<tr>
<td>14-18 years</td>
<td>2672</td>
<td>2780</td>
<td>1</td>
</tr>
</tbody>
</table>

Regular review of the dietary prescription is essential

Infant with CKD 5
- Expected weight gain 200gm per week
- So, if weight ↑ from 3.5 to 3.9 kg over 2 weeks
  - Protein needs to increase from 8.75 to 9.75g
    - (based on 2.5gm protein/kg/day)
  - Calories from 490 to 546
    - (based on 140cals/kg/day)
  - Volume from 525 to 585mls
    - (based on 150ml/kg/day)

Frequency of Nutrition Assessment
Days 4 to 5

- Urinary sodium high
- Decreasing weight and BP
- Plasma changes below

<table>
<thead>
<tr>
<th>Day of life</th>
<th>Na mmol/l</th>
<th>K mmol/l</th>
<th>HCO3 mmol/l</th>
<th>Urea mmol/l</th>
<th>PO4 mmol/l</th>
<th>Ca mmol/l</th>
<th>Creatinine mmol/l</th>
<th>Wt kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>130</td>
<td>4.8</td>
<td>28</td>
<td>3.4</td>
<td>2.0</td>
<td>2.32</td>
<td>100</td>
<td>2.1</td>
</tr>
<tr>
<td>2</td>
<td>128</td>
<td>5.4</td>
<td>24</td>
<td>6.8</td>
<td>2.16</td>
<td>2.18</td>
<td>120</td>
<td>2.0</td>
</tr>
<tr>
<td>3</td>
<td>126</td>
<td>5.8</td>
<td>20</td>
<td>8.0</td>
<td>2.26</td>
<td>2.10</td>
<td>140</td>
<td>1.9</td>
</tr>
<tr>
<td>4</td>
<td>124</td>
<td>6.0</td>
<td>18</td>
<td>10.0</td>
<td>2.41</td>
<td>1.96</td>
<td>160</td>
<td>1.8</td>
</tr>
</tbody>
</table>

Options: Would you

- Give it a bit more time
- Stop the breast feeding and change to formula
- Insert a nasogastric tube to provide the daily nutritional requirements as top up to oral feeds
- Insert a nasogastric tube to provide the daily nutritional requirements as formula and allow breast feeds as ‘extra’
- Start a sodium supplement
- Start sodium bicarbonate

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- Start sodium bicarbonate
Day 5

- Calcium 1.96 mmol/l
- Phosphate 2.41 mmol/l
- PTH 30 pmol/l
- Alkaline phosphatase 400 u/l

- The calcium intake is 200 mg/day
- The feed provides 1.2 mcg 25(OH)D per 100mls
- The phosphate intake is 80 mg

Options: Would you

- Increase the calcium intake
- Restrict the phosphate intake
- Give 25(OH)D
- Give 1,25(OH)D3
- Give calcium carbonate or calcium acetate
- Give sevelamer

Options: Would you

- Increase the calcium intake
- Restrict the phosphate intake
- Give 25(OH)D supplement
- Give 1,25(OH)2D
- Give calcium carbonate or calcium acetate
- Give sevelamer
Management of calcium balance and control of bone disease

- The daily calcium balance in the first year of life is 500-600g, which is higher than at any other age
- Upper and lower limits of RNI are 524mg and 240mg/day
- Standard whey based formula has approx 5mg/ml of calcium
- We do not know how much calcium is absorbed from calcium containing PO4 binders
- The normal range for calcium is high in the first year of life

Serum Calcium levels

NEW 4.1.3: In children with CKD Stages 3a–5D, we suggest maintaining serum calcium in the age-appropriate normal range. (2C)

In children with CKD Stages 3a–5D, it is reasonable to base the choice of phosphate-lowering treatment on serum calcium levels. (Not Graded)

In children, calcitriol and vitamin D analogs may be considered to maintain serum calcium levels in the age-appropriate normal range (Not Graded).

Phosphate

- Upper limit for intake is 400mg
- Serum phosphate is high in infancy
- Phosphate content is low:
  - Breast milk 14mg/100ml
  - Whey based infant formulas on average 27mg per 100ml
- Phosphate binders may still be required
NEW 4.1.1: In patients with CKD Stages 3a–5D, treatments of CKD-MBD should be based on serial assessments of phosphorus, calcium and PTH levels, considered together. (Not Graded)

NEW 4.1.2: In patients with CKD Stages 3a–5D, we suggest lowering elevated phosphorus levels towards the normal range. (2C)

It is reasonable to consider phosphate source (e.g., animal, vegetable, additives) in making dietary recommendations. (Not Graded)
Case

- The weight and BP increase.
- Urine output falls to 0.5/ml/kg/hr
- There is oedema
- The bloods deteriorate

<table>
<thead>
<tr>
<th>Day</th>
<th>Na</th>
<th>K</th>
<th>HCO₃</th>
<th>Urea</th>
<th>PO₄</th>
<th>Calcium</th>
<th>Creatinine</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>124</td>
<td>6.2</td>
<td>20</td>
<td>10.0</td>
<td>2.3</td>
<td>1.96</td>
<td>160</td>
<td>2.0</td>
</tr>
<tr>
<td>2</td>
<td>122</td>
<td>6.4</td>
<td>19</td>
<td>14.0</td>
<td>2.5</td>
<td>1.94</td>
<td>190</td>
<td>2.2</td>
</tr>
<tr>
<td>3</td>
<td>120</td>
<td>6.6</td>
<td>18</td>
<td>16.0</td>
<td>2.8</td>
<td>1.90</td>
<td>220</td>
<td>2.3</td>
</tr>
</tbody>
</table>

Options: Would you

- Change all feed to a low electrolyte formula (e.g. Renastart)
- Substitute some of the whey based formula with a low electrolyte formula
- Add in proprietary vitamins
- Start dialysis

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- Substitute some of the whey based formula with a low electrolyte formula
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Low electrolyte feeds

<table>
<thead>
<tr>
<th>Feed</th>
<th>Energy (kcal)</th>
<th>Protein (g)</th>
<th>Potassium (mmol)</th>
<th>Calcium (mg)</th>
<th>Phosphorus (mg)</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>410ml 13% typical standard infant formula</td>
<td>410</td>
<td>5.2</td>
<td>6.6</td>
<td>-</td>
<td>-</td>
<td>98</td>
</tr>
<tr>
<td>410ml 13% Renastart renal infant formula</td>
<td>410</td>
<td>4.1</td>
<td>2.5</td>
<td>-</td>
<td>-</td>
<td>49</td>
</tr>
<tr>
<td>50:50 mixture</td>
<td>410</td>
<td>4.7</td>
<td>4.6</td>
<td>-</td>
<td>-</td>
<td>74</td>
</tr>
</tbody>
</table>

Case

- Good fluid balance but weight static

Results

- HB 10.4g/dl
- TSAT 30%
- Na 138mmol/l
- K 4.0 mmol/l
- HCO3 27mmol/l
- urea 5.2mmol/l
- Creatinine 280mmol/l
- albumin 28g/l
- Ca 2.5mmol/l
- P 1.8mmol/l
- PTH 5.6pmol/l

Medications

- Erythropoietin 500u x 2 per week
- Sytron 1ml daily
- Calcium carbonate 1,25(OH)2D 0.2mcg daily
- NaCl 1mmol/kg x 2 daily

Dialysis CCPD

- 16 hours, 14 cycles
- Fill volume 800ml/m2
- Last bag fill 400ml/m2
- All 1.36% dialysate

Options: Would you

- Increase the dialysis
- Change any of the medications
- Increase the protein and calorie content of the feed
- Concentrate the feeds
- Add a vitamin and mineral supplement
- Start growth hormone
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- Change any of the medications
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- Concentrate the feeds
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Concentrating feeds to meet protein requirements for PD

- Aim for a urea < 20mmol/L, normal serum albumin and normal growth
- 160ml/kg for 2.3kg baby = 370ml
- Replace 0.28g/kg/day transperitoneal protein losses
- Increase energy intake
- The normal feed concentration of 13% is increased to 16%

<table>
<thead>
<tr>
<th>Name of the concentrated renal infant formula</th>
<th>Protein (g)</th>
<th>K (mmol)</th>
<th>PO4 (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>160ml 15% concentrated Renastart renal infant formula</td>
<td>2.1</td>
<td>1.3</td>
<td>25</td>
</tr>
<tr>
<td>per kg</td>
<td>2.26</td>
<td>2.3</td>
<td>83</td>
</tr>
</tbody>
</table>

Protein intake - KDOQI

Protein Stage 3: 100% - 140% Dietary Reference Intake (DRI) for ideal body weight
Stage 4 - 5: 100% - 120% DRI for ideal body weight
HD DRI = 0.1 g/kg/d
PD DRI = 0.15 - 0.3 g/kg/d (depending on patient age to compensate for peritoneal losses)

<table>
<thead>
<tr>
<th>Age</th>
<th>DRI (g/kg/d)</th>
<th>HD (g/kg/d)</th>
<th>PD (g/kg/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-6 months</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>7-12 months</td>
<td>1.2</td>
<td>1.3</td>
<td>1.5</td>
</tr>
<tr>
<td>1-3 years</td>
<td>1.05</td>
<td>1.15</td>
<td>1.3</td>
</tr>
<tr>
<td>4-13 years</td>
<td>0.95</td>
<td>1.05</td>
<td>1.1</td>
</tr>
<tr>
<td>14-18 years</td>
<td>0.85</td>
<td>0.95</td>
<td>1.0</td>
</tr>
</tbody>
</table>
Case

- The baby continues to vomit with static growth despite
  - a continuous drip feed
  - maximum concentration of feeds
  - medications
  - optimised dialysis

Options: Would you

- Consider total parenteral nutrition
- Arrange a percutaneous gastrostomy
- Arrange a surgically placed gastrostomy

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- Arrange a percutaneous gastrostomy
- Arrange a surgically placed gastrostomy
Who is offered rhGH?
Most centres would offer rhGH to children with
• Ht SDS < -2SD and
• Ht velocity SDS < 25th centile despite optimal medical management

Factors affecting response to rhGH
- age
- Ht SDS and Ht velocity SDS
- severity of CKD, both before and after transplant
- adequacy of dialysis
- steroid therapy and dosage
- nutrition and metabolic control
- compliance

Cochrane Renal Group review of rhGH

10 RCTs involving 481 children
- 28 IU/m²/week for 1 year results in an average height increase of 4 cm regardless of pubertal stage and severity of CKD
- any benefit of continuing treatment is uncertain
- it is not known if the increase in height over one year will increase final height
- side effects are no different to controls

Conclusions
• Careful attention to nutritional requirements and early intervention is critical to prevent malnutrition rather than treat it.
• Input from a paediatric renal dietitian is essential
• Enteral feeding improves growth in (many) children on dialysis
• Caution with gastrostomy placement in children on PD
• Protein requirements increase in the child on PD and must be frequently monitored
Thank you!