NUTRITION MANAGEMENT OF INFANT WITH RENAL DISEASES

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OBJECTIVES

* To understand why premature infants are at higher risk for renal failure

* To learn unique nutrition requirements of premature infants

* To review causes of CKD (Chronic Kidney Disease) in newborns

* To apply pediatric renal nutrition goals in the setting of premature/term infants with CKD
1. NICU basics
2. Nephrogenesis and prematurity
3. Premature nutrient requirements
4. Renal Disease in Neonates
5. Intervention – Medical and Nutrition
1. NICU BASICS

Newborn classifications
Anthropometric goals
Growth charts
### Classifications

<table>
<thead>
<tr>
<th>Classification</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gestational Age</strong></td>
<td></td>
</tr>
<tr>
<td>Premature</td>
<td>&lt;37 wks</td>
</tr>
<tr>
<td>Term</td>
<td>37 – 42 wks</td>
</tr>
<tr>
<td>Post-term</td>
<td>&gt;42 wks</td>
</tr>
<tr>
<td><strong>Birth Weight</strong></td>
<td></td>
</tr>
<tr>
<td>LBW</td>
<td>&lt;2500 g</td>
</tr>
<tr>
<td>VLBW</td>
<td>&lt;1500 g</td>
</tr>
<tr>
<td>ELBW</td>
<td>&lt;1000 g</td>
</tr>
<tr>
<td><strong>Weight for Age</strong></td>
<td></td>
</tr>
<tr>
<td>SGA</td>
<td>&lt;10\textsuperscript{th} percentile</td>
</tr>
<tr>
<td>AGA</td>
<td>10\textsuperscript{th} to 90\textsuperscript{th} percentile</td>
</tr>
<tr>
<td>LGA</td>
<td>&gt;90\textsuperscript{th} percentile</td>
</tr>
</tbody>
</table>
## Anthropometric Goals

<table>
<thead>
<tr>
<th></th>
<th>Premature</th>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>15-20 g/day</td>
<td>20 – 30 g/day</td>
</tr>
<tr>
<td>Length</td>
<td>0.8-1.1 cm/week</td>
<td>0.69-0.75 cm/week</td>
</tr>
<tr>
<td>HC</td>
<td>0.5-0.6 cm/week</td>
<td>0.5 cm/week</td>
</tr>
</tbody>
</table>
2. NEPHROGENESIS AND PREMATURITY
Nephrogenesis and Prematurity

- Nephrogenesis starts 22 days after conception and start function at 37 days.
- Continues until 36 wks gestation - then it’s over!
- 60% of nephrons are formed during the 3rd trimester
- Autopsy studies have shown a very strong correlation between BW, GA, and glomerular number and size
Consequences

Franke D. et al, 2010

* 435 children with CKD
* Prevalence of SGA was 3 X higher in children with CKD compared to normal controls
* 1/3 of children with CKD born premature

Greenbaum et al, 2011

* Analysis of CkiD study
* 400 children with CKD
* 17% were LBW
* 14% were SGA
* 40% were in a NICU
* LBW and SGA higher incidence of short stature
TAKE HOME MESSAGE

* Assume some degree of renal insufficiency when assessing premature infants in the NICU

* Remember the higher risk these children will have for CKD as they get older
3. PREMATURE NUTRIENT REQUIREMENTS
### Normal Nutrient Needs for Premature Infants

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Parenteral</th>
<th>Enteral</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Calories</strong></td>
<td>90-100 kcals/kg</td>
<td>110-150 kcals/kg*</td>
</tr>
<tr>
<td><em>120 kcals/kg is typical initial goal</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Protein</strong></td>
<td>3.2-4.0 g/kg</td>
<td>3.4 – 4.4 g/kg</td>
</tr>
<tr>
<td><strong>Sodium</strong></td>
<td>3-5 meq/kg/d</td>
<td>3-5 meq/kg/d</td>
</tr>
<tr>
<td><strong>Potassium</strong></td>
<td>2-3 meq/kg/d</td>
<td>2-3 meq/kg/d</td>
</tr>
<tr>
<td><strong>Calcium</strong></td>
<td>60-80 mg/kg/d</td>
<td>100 – 220 mg/kg/d</td>
</tr>
<tr>
<td><em>Term: 210 mg/day</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Phosphorous</strong></td>
<td>45-60 mg/kg/d</td>
<td>60 – 140 mg/kg/d</td>
</tr>
<tr>
<td><em>Term: 100 mg/day</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fluid</strong></td>
<td>90-180 mls/kg/d</td>
<td>90-220 mls/kg/d*</td>
</tr>
<tr>
<td><em>150 mls/kg is typical goal</em></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Tsang 2005
Protein Needs by Gestational Age

Adapted from Tsang, et al 2005

For a complete listing of all nutrient requirements recommended see Tsang, et al 2005

<table>
<thead>
<tr>
<th>Gestational Age</th>
<th>Protein (g/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>26 - 30 weeks</td>
<td>3.8 – 4.4</td>
</tr>
<tr>
<td>30 - 36 weeks</td>
<td>3.4 – 4.2</td>
</tr>
<tr>
<td>36 – 40 weeks</td>
<td>2.8 – 3.4</td>
</tr>
</tbody>
</table>
In General, Nutrient Needs are Higher for Premature Infants. Goal is to Provide Nutrient Concentrations that will match Fetal Accretion Rates.
4. RENAL DISEASE IN NEONATES

A. Acute Kidney Injury (AKI)
# Incidence of AKI

## TABLE 1
Recent Estimates of AKI Incidence in Various Neonatal Populations

<table>
<thead>
<tr>
<th>Study</th>
<th>Study Population</th>
<th>AKI Definition</th>
<th>Number of Infants</th>
<th>AKI Incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viswanathan et al</td>
<td>Extremely LBW (&lt;1000 g)</td>
<td>Serum creatinine ≥1.5 mg/dL or urine output &lt;1 mL/kg/h</td>
<td>472</td>
<td>12.5%</td>
</tr>
<tr>
<td>Koralkar et al</td>
<td>Very LBW (&lt;1500 g)</td>
<td>AKIN&lt;sup&gt;85&lt;/sup&gt;</td>
<td>229</td>
<td>18%</td>
</tr>
<tr>
<td>Selewski et al</td>
<td>Asphyxiated newborns undergoing therapeutic hypothermia</td>
<td>AKIN</td>
<td>96</td>
<td>38%</td>
</tr>
<tr>
<td>Kaur et al</td>
<td>Infants ≥34 wk gestation with asphyxia (Apgar &lt;7 at 1 min after birth)</td>
<td>AKIN</td>
<td>36</td>
<td>41.7%</td>
</tr>
<tr>
<td>Blinder et al</td>
<td>Infants &lt;90 d old with congenital heart disease undergoing surgery</td>
<td>AKIN</td>
<td>430</td>
<td>52%</td>
</tr>
<tr>
<td>Gadepalli et al</td>
<td>Infants with congenital diaphragmatic hernia requiring extracorporeal membrane oxygenation</td>
<td>RIFLE&lt;sup&gt;147&lt;/sup&gt;</td>
<td>68</td>
<td>71%</td>
</tr>
</tbody>
</table>
Box 1. Proposed neonatal AKI classification


<table>
<thead>
<tr>
<th>Stage</th>
<th>SCr</th>
<th>Urine Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No change in SCr or increase &lt;0.3 mg/dL</td>
<td>≥0.5 mL/kg/h</td>
</tr>
<tr>
<td>1</td>
<td>SCr increase ≥0.3 mg/dL within 48 h or SCr increase ≥1.5–1.9 × reference SCr³ within 7 d</td>
<td>&lt;0.5 mL/kg/h for 6–12 h</td>
</tr>
<tr>
<td>2</td>
<td>SCr increase ≥2 to 2.9 × reference SCr³</td>
<td>&lt;0.5 mL/kg/h for ≥12 h</td>
</tr>
<tr>
<td>3</td>
<td>SCr increase ≥3 × reference SCr³ or SCr ≥2.5 mg/dL or Receipt of dialysis</td>
<td>&lt;0.3 mL/kg/h for ≥24 h or anuria for ≥12 h</td>
</tr>
</tbody>
</table>

*Baseline SCr is defined as the lowest previous SCr value.*

AKI Causes

- Prerenal
- Renal (Intrinsic)
- Postrenal

Remember that AKI can occur in both non-CKD babies as well as CKD babies
Usually due to **inadequate renal perfusion**

- Dehydration

Kidney is intrinsically normal

- But remember nephrogenesis not complete if premature

**Most common reason for AKI in NICU**

Can lead to CKD if not corrected: ATN and/or acute cortical necrosis with scarring
AKI
INTRINSIC

- **ATN** - from ischemic/hypoxic events

- **Drug Induced** - Gentamicin, Tobramycin, Ibuprofen, Indomethacin

- **Vascular Insults** – Renal (artery or vein) Thrombosis

- **Infectious** – Sepsis, Pyelonephritis
AKI

POSTRENAL

* Obstructive Uropathy
* Post Urethral Valves
* Neurogenic Bladder
4. RENAL DISEASE IN NEONATES

B. CHRONIC KIDNEY DISEASE (CKD)
Disorders resulting in neonatal CKD


- Aplastic/hypoplastic/dysplastic kidneys
- Autosomal dominant polycystic kidney disease
- Autosomal recessive polycystic kidney disease
- Obstructive uropathy (posterior urethral valves)
- Pyelonephritis
- Reflux nephropathy
- Renal infarct
- Syndrome of agenesis of abdominal musculature

*a* May result in need for dialysis in neonatal period.
The typical diagnostic criteria of GFR < 60 (KDOQI) does not apply until > 2 years old.

The updated Schwartz formula: \( eGFR = 0.413 \times \frac{\text{height}}{\text{Scr}} \) does not apply in children 0 – 2 yrs old

Normal GFR in newborn period is significantly < 60
Glomerular filtration rate (GFR) in healthy infants as assessed by inulin clearance

<table>
<thead>
<tr>
<th>Age</th>
<th>Mean GFR ± SD (mL/min/1.73 m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preterm babies</td>
<td></td>
</tr>
<tr>
<td>1–3 d</td>
<td>14.0 ± 5</td>
</tr>
<tr>
<td>1–7 d</td>
<td>18.7 ± 5.5</td>
</tr>
<tr>
<td>4–8 d</td>
<td>44.3 ± 9.3</td>
</tr>
<tr>
<td>3–13 d</td>
<td>47.8 ± 10.7</td>
</tr>
<tr>
<td>8–14 d</td>
<td>35.4 ± 13.4</td>
</tr>
<tr>
<td>1.5–4 mo</td>
<td>67.4 ± 16.6</td>
</tr>
<tr>
<td>Term babies</td>
<td></td>
</tr>
<tr>
<td>1–3 d</td>
<td>20.8 ± 5.0</td>
</tr>
<tr>
<td>3–4 d</td>
<td>39.0 ± 15.1</td>
</tr>
<tr>
<td>4–14 d</td>
<td>36.8 ± 7.2</td>
</tr>
<tr>
<td>6–14 d</td>
<td>54.6 ± 7.6</td>
</tr>
<tr>
<td>15–19 d</td>
<td>46.9 ± 12.5</td>
</tr>
<tr>
<td>1–3 mo</td>
<td>85.3 ± 35.1</td>
</tr>
</tbody>
</table>

**KDIGO classification schemata for CKD for ages less than 2 years**

<table>
<thead>
<tr>
<th>Neonatal CKD Classification</th>
<th>GFR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal GFR</td>
<td>GFR ≤1 SD below the mean</td>
</tr>
<tr>
<td>Moderately reduced GFR</td>
<td>GFR &gt;1 SD to ≤2 SD below the mean</td>
</tr>
<tr>
<td>Severely reduced GFR</td>
<td>GFR &gt;2 SD below the mean</td>
</tr>
</tbody>
</table>

**Abbreviations:** KDIGO, Kidney Disease: Improving Global Outcomes; SD, standard deviation.


**Abbreviation:** SD, standard deviation.

Factors Influencing Lab Assessment
BUN

* Normal BUN levels are higher with lower GA and BW

* Elevated BUN levels are often cited as reason for limiting AA or protein intake

- 249 infants, all <30 wks gestation at birth
- Provided recommended protein/AA intakes over the 1st 3 weeks of life (range: 2.1 – 3.9 g/kg)
- Measured BUN, Cr and protein/AA intake for each week
Weintraub AS et al 2015
Creatinine

- High at birth; reflects mother’s level.
- Transient increase (2-5 days) initially reflecting diuresis. Can take up to 3-4 wks to normalize in a premature infant.
- These higher levels the 1st month also reflect incomplete nephrogenesis.
- Normal range:
  - Newborn: .3-1.0 mg/dl
  - Infant: .2-.4 mg/dl
Factors Influencing Lab Assessment

**Phosphorus**

* Normal reference range 4.2 – 8.5mg/dl
* Premies have very high phosphorous requirements.

**Potassium**

* Hyperkalemia is common but may not be real.
* Beware of false elevation due to frequent heel sticks and hemolysis.
* Potassium will be elevated if baby is acidotic.
Sodium and Water

- Term and preemies undergo 10 – 20% loss of ECF immediately after birth.
- Term: regains BW in 7-10 days
  Preterm: regains BW in 14-21 days
- Fluid loss accompanied by Sodium loss.
- In Preemies: Renal Na losing state is greater and more prolonged. Most normal premies may temporarily require Na suppl. (even without dx of CKD)
Fractional Excretion of Sodium (FENa) is inversely related to GA. The lower the GA, the higher the loss of Na.

FENa: \[\frac{(UNa/PNa)}{(UCr/PCr)} \times 100\%\]

- Normal FENa is <1%.

If there is AKI/CKD, with normal or high urine output, the Na supplementation needed may be higher.
- Examples are recovering ATN in AKI and obstructive uropathy with tubular damage in CKD. (Exception: anuric/oliguric and not on dialysis)
5. INTERVENTION

Medical and Nutrition
INTERVENTION:

A. Medical

- Management of fluid balance
- Management of electrolytes
- Acid/Base Balance
- Renal Replacement Therapy (RRT)
MANAGEMENT OF FLUID BALANCE

- Maintenance fluid = 100 ml/kg/d
- Typical fluids to meet kcal needs with 24 Kcals/oz feedings = 150mls/kg
- If Anuric/Oliguric may need severe fluid restrictions (i.e. 60 – 80 ml/kg/d)
- Requires concentration of formulas (up to 60 kcals/oz) and/or concentration of TPN
- If Polyuric, fluid needs may increase up to 200-250mls/kg/d (examples would be in babies with concentrating defects)
MANAGEMENT of ELECTROLYTES

HYPONATREMIA

- May require fluid restriction
- May require Sodium supplementation
  - If very premature
  - If there is a sodium losing component with renal failure
    - Calculate FENa
  - If baby is on peritoneal dialysis
- Sodium can be increased in TPN or NaCL added to formula
- Phos and bicarb supplementation will also increase the Na supplementation
Hyperkalemia is common

- Beware of false elevations (i.e. heel sticks)
- Change feedings to lower K content
- Remove K from TPN or titrate down
- Kayexalate can be added to formula followed by decanting
  - 1 g kayexalate for each meq of K removed
  - Range of 0.5-1.5g Kayexalate per 100 mls EBM or formula
- Dialysis may be necessary
MANAGEMENT of ELECTROLYTES
HYPERPHOSPHATEMIA

- Remember... the normal reference range for phosphorous
  - For premies: 4.2 – 8.5mg/dl
  - For term: 4.2 – 7.0mg/dl

- If phosphorous is above those ranges
  - Use Low Phos formula (Kindergen) and/or Breast Milk
  - Add liquid Calcium Carbonate to formula to bind

- Phos is likely to go too low once dialysis started
  - Titrate down or stop dose of calcium carbonate
  - May need phos supplementation (sodium phosphate: 93 mg/ml)
MANAGEMENT of ELECTROLYTES
ACID/Base BALANCE

* Metabolic Acidosis
  * Very common in AKI
  * Ongoing issue in CKD
* Treated with Sodium Bicarbonate, Sodium Citrate or Dialysis
* Remember...
  * Acidotic babies will not gain weight or grow
  * Treatment will add to sodium intake so it needs to be accounted for if you are also using NaCl
  * Acidosis can cause the hyperkalemia!
Peritoneal Dialysis is predominant choice

Literature cites premies as low as 930 g getting long term PD and smaller for short term PD

Hemodialysis: depends on expertise available

CRRT: depends on expertise
- As low as 1500 g
- HD and CRRT not good long term options due to frequent clotting and infection.
INTERVENTION

B. NUTRITION
## 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>From:</td>
<td>Conception to birth</td>
<td>Birth -18 mos</td>
<td>18 mos -12 yrs</td>
<td>Onset of puberty</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</td>
<td>Growth H</td>
<td>Testosterone, Estrogen</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Good Health</td>
<td>Thyroid H.</td>
<td>Growth hormone</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Good Health</td>
<td>Good Health</td>
</tr>
</tbody>
</table>
Nutritional Challenges In Infants with CKD

- Anorexia
  - Chewing/swallowing problems
  - Delayed stomach emptying
  - Vomiting, GER
  - Psychogenic

- Dialysis
  - Vomiting, Peritonitis

- Metabolic acidosis
  - Medications
  - Catch-up growth

- ↓ intake
- ↑ losses
- ↑ needs

Energy &/or Protein Deficit

Poor growth/FTT

**Tube feeding** is frequently required to meet nutritional requirements and optimize growth in infants with CKD.
### NUTRITION

#### Calories

**Term Infants**

**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>$EER = [89 \times \text{weight (kg)} - 100] + 175$</td>
</tr>
<tr>
<td>4-6 mo</td>
<td>$EER = [89 \times \text{weight (kg)} - 100] + 56$</td>
</tr>
<tr>
<td>7-12 mo</td>
<td>$EER = [89 \times \text{weight (kg)} - 100] + 22$</td>
</tr>
</tbody>
</table>
## NUTRITION

### Protein

* Term Infants

<table>
<thead>
<tr>
<th>Age</th>
<th>DRI (g/kg/d)</th>
<th>Recommended for CKD Stage 3 (100%-140% DRI)</th>
<th>Recommended for CKD Stages 4-5 (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>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>
</tbody>
</table>
CALORIE AND PROTEIN RECOMMENDATIONS

Premature

<table>
<thead>
<tr>
<th></th>
<th>KCALS</th>
<th>PROTEIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSERVATIVE</td>
<td>110 – 150 kcals/kg</td>
<td>3.4 – 4.4 g/kg</td>
</tr>
<tr>
<td>PERITONEAL DIALYSIS</td>
<td>110 – 150 kcals/kg</td>
<td>?</td>
</tr>
<tr>
<td>HEMODIALYSIS</td>
<td>110 – 150 kcals/kg</td>
<td>?</td>
</tr>
</tbody>
</table>

- No published references on Protein needs for Premies on dialysis

- If term baby recs. are to increase Protein intake by .1-.35 g/kg/day (K/DOQI 2008) then a conservative approach would be to increase preemies protein intake above normal needs by .1g/kg (for HD) and .35 g/kg (for PD)

- With HD protein needs increase: 3.5-4.5 g/kg/day

- With PD protein needs increase: 3.75-4.75g/kg/day
## Protein Recommendations by Gestational Age

<table>
<thead>
<tr>
<th>Gestational Age</th>
<th>Conservative* g/kg</th>
<th>PD g/kg</th>
<th>HD g/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>26 – 30 wks</td>
<td>3.8 – 4.4</td>
<td>4.15 – 4.75</td>
<td>3.9 – 4.5</td>
</tr>
<tr>
<td>30 – 36 wks</td>
<td>3.4 – 4.2</td>
<td>3.75 – 4.55</td>
<td>3.5 – 4.3</td>
</tr>
<tr>
<td>36 – 40 wks</td>
<td>2.8 – 3.4</td>
<td>3.15 – 3.75</td>
<td>2.9 – 3.5</td>
</tr>
</tbody>
</table>

*Adapted from Tsang, 2005*
Monitor growth parameters closely

Start by determining fluid needs - anuric, oliguric, normal, polyuric? - with or without dialysis?

Make modifications to calorie or protein intake based on your assessment of current calorie intake, protein intake, growth.

Monitor BUN:Cr Ratio

- Normal ratio is 10-20:1
- If ratio is high: perhaps not enough calories, too much protein or breakdown of lean body mass, dehydration, needs more dialysis?
- If ratio is low: not enough protein, fluid overload
* Need to meet the requirements of the Term or Premature Infant
* If K or Phos restriction warrants a change from normal premature feedings, then **MVI** supplements will be needed
* Use **single Mineral supplements** to provide mineral requirements (i.e. CaCO3, Ferinsol, NaPhosphate, KCl)
* Watch **Calcium and Phosphorous** levels closely
  * Remember the increased needs of premies
  * May need both Calcium and Phos. supplementation
* Watch **Sodium** levels closely.
  * Premies, Polyuric, and PD babies tend to be salt wasters.
* May need additional **B vitamins** and **Vit C** if on dialysis.
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
Nutrient needs are high for premies. But because of high serum K and Phos with renal failure… Premature formulas are discontinued and Fortified Breast Milk is stopped.

Usual practice is to start kindergen or unfortified Breast Milk: then concentrate as needed.

Supplementation of individual nutrients may be necessary: MVI, iron, Na, Ca and Phos.

Individual nutrient supplementation will likely increase once dialysis is started.
## 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>Kindergen (30)</td>
<td>100</td>
<td>1.5</td>
<td>46.4</td>
<td>24</td>
<td>22.4</td>
<td>18.6</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>

**IDEAL FORMULA:** LOW RENAL SOLUTE, LOW P, K, and HIGH Calories
∗ Determine urine output status of infant: anuric, oliguric, normal, polyuric

∗ Determine fluid status of infant: dehydrated, normal hydration, edematous

∗ If fluids restricted to maintenance fluid (100 ml/kg) Requires 36 kcals/oz to meet basic premie needs and 32 kcals/oz to meet term needs.

∗ If more fluid restricted (ie 60-80 ml/kg) then greater concentration required.
Increase formula powder to fluid (water or breast milk) ratio until protein needs are met.

Use carbohydrate/fat modulars for additional concentration if necessary to meet calorie goals.
Modular Products
If highly polyuric, formula may need to be prepared to less than 20 kcals/oz

There are 2 ways to do this:

- Prepare recipes for less than 20 kcals/oz – (i.e. 14, 16, 18 etc)
- Prepare 20 kcals/oz feedings but instruct on giving additional water
Thank You !