The Kidney Conundrum: Nutrition Considerations in AKI and CKD

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Learning Objectives

1. Evaluate recommendations and evidence for calorie and protein goals for hospitalized patients with chronic kidney disease (CKD) and acute kidney injury (AKI).

2. Describe considerations for adjusting macronutrient provision based on the potential for caloric losses and gains associated with continuous renal replacement therapy (CRRT).

3. Highlight unique electrolyte and mineral replacement requirements in patients with kidney disease.
Kidney Disease & Malnutrition

- AKI: 5-25% of hospitalized patients
- ESRD: 1-9% of ICU admissions
- RRT: 5% of hospitalized patients
- Malnutrition (PEW, PCM): up to 40% of AKI

Fiaccadori E, Seminares in Dialysis, 2011;24:169-75.
Malnutrition in Kidney Disease

- Comorbid state
- Acute illness, catabolism
- Renal failure syndrome

- ↑ length of stay
- ↑ complications
- ↑ in-hospital morality

Nutrition support & kidney disease: State of the evidence?

- ASPEN’s 2010 Clinical Guidelines: Nutrition Support in Adult Acute and Chronic Renal Failure: Recommendations graded C – E
- ESPEN 2009 Guidelines on PN: Adult Renal Failure: “From a metabolic point of view, patients with CKD or on chronic HD who develop a superimposed acute illness should be considered to be similar to patients with acute renal failure.” [GRADE C]
- Cochrane Database of Systematic Reviews (2012): “..due to the small number of participants and the poor quality of some studies, we are unable to provide recommendations for the use of nutritional support for treating AKI.”
Case: A PN Consult

• 58F, s/p radical subtotal gastrectomy with Roux-en-Y gastrojejunostomy, now with tube feeds leaking from the midline wound
• Sinogram: Duodenal stump leak/fistula
• PMH: Stage 5 CKD on IHD, gastric Ca, DM2, HTN
Case

• **Anthropometrics**
  – Current weight 70 kg
  – Dry weight 63 kg
  – BMI 23.1

• **Physical exam**
  – General: Alert and oriented
  – Heart: RRR
  – Skin: 3+ edema, LE
  – Abdomen: JP drain

• **Current medications**
  – Acetaminophen
  – Heparin SQ
  – Aspart insulin (CSI)
  – Ondansetron
  – Piperacillin/tazobactam
  – Oxycodone

• **Fluids**
  – 0.9% NaCl 20 ml/h
Venous access

- L IJ tunneled dialysis catheter is present; an old R AV fistula has clotted off
- A PICC (L upper arm) was placed yesterday, but prior to placement “The patient's primary service was contacted with the recommendation of consulting with Nephrology before a PICC line is inserted.”
Venous access considerations

• PICC: Independent risk factor for lack of functioning AV fistula
  – Case-control, n = 282
  – Prior PICC in 44.2% of cases vs. 19.7% controls (successful AVF) (P 0.001)

• Harm: thrombosis, vascular sclerosis, stenosis
Question #1

The recommended amount of calories to provide our patient is:

a) 10 - 15 kcal/kg/day
b) 30 - 35 kcal/kg/day
c) 100-120% of predicted basal energy expenditure
d) Predicted basal energy expenditure x 1.5-1.7
## Energy requirements?

<table>
<thead>
<tr>
<th>Guideline</th>
<th>Energy Goal (daily)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASPEN/SCCM (2016): Nutrition support in adult</td>
<td>25 – 30 kcal/kg</td>
<td>• AKI</td>
</tr>
<tr>
<td>critically ill patient</td>
<td></td>
<td>• Quality of Evidence: Very Low (expert consensus)</td>
</tr>
<tr>
<td>ASPEN (2010): Adult acute and chronic renal</td>
<td>Use indirect calorimetry when</td>
<td>• Grade D</td>
</tr>
<tr>
<td>failure</td>
<td>available</td>
<td></td>
</tr>
<tr>
<td>ESPEN (2009, 2006): PN and EN in adult renal</td>
<td>20-30 kcal/kg</td>
<td>• Energy requirements are determined “by severity of underlying disease,</td>
</tr>
<tr>
<td>failure</td>
<td></td>
<td>type and intensity of RRT, nutrition status and associated complications</td>
</tr>
<tr>
<td></td>
<td></td>
<td>rather than ARF itself”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Grade C</td>
</tr>
<tr>
<td>KDIGO (2012)</td>
<td>20-30 kcal/kg</td>
<td>• Grade 2C</td>
</tr>
</tbody>
</table>
• AKI or CKD in ICU

• AKI, requiring CRRT; n = 1456
• Mean daily caloric intake (DCI): 11 kcal/kg/d
• No association of DCI with mortality, RRT-, ICU-, or hospital-free days
• DCI > 25 kcal/kg/d was not associated with improved outcome

• 30 vs 40 kcal/kg/d
• Higher kcal = increased metabolic intolerance
**INTACT: Braunschweig C, et al. JPEN 2015**
- Prospective, single-center RCT
- 78 critically ill adults, acute lung injury
  - Intensive medical nutrition therapy (> 75% estimated daily energy and protein needs via EN/PO; mean 1798 kcal/d)
  - Standard nutrition support care (mean 1221 kcal/d, P <0.0001)
- Trial stopped early because of significantly greater hospital mortality in IMNT vs SNSC (40% vs 16%, P = 0.02)

- Prospective, multicenter RCT
- 894 adults, fed within 48h ICU admit
  - Permissive underfeeding: 40-60% daily requirements
  - Standard: 70-100%
  - Similar protein
- No difference in mortality
- Permissive underfeeding: Lower glucose levels, less insulin, and lower daily fluid balance on several study days; post-hoc, less RRT
Question #1

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Question #2

You are starting PN in 48M with BMI 38 kg/m²; ischemic bowel, ATN, AKI. No RRT; transferred to floor post-op. What amount of protein would you give in the PN? SCr/BUN 2.4, 54, UOP 2.4 L / 24 h.

a) 0.8 g/kg estimated lean weight
b) 0.8 g/kg adjusted body weight
c) 1.5 g/kg estimated lean weight
d) 1.5 g/kg adjusted body weight
## Considerations for more:

1. **RRT or no RRT?**
2. **What type of RRT?**

### What to monitor?
- **Obesity/overweight**
- **Critical illness**
- **Wounds, large bone fractures, multiple trauma, burns**

### Guidelines

<table>
<thead>
<tr>
<th>Guideline</th>
<th>Protein Intake</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASPEN/SCCM (2016)</td>
<td>1.2–2.5 g/kg</td>
</tr>
<tr>
<td>ASPEN (2010)</td>
<td>1.8–2.5 g/kg</td>
</tr>
<tr>
<td>ASPEN (2009, 2006)</td>
<td>1.5–1.7 g/kg</td>
</tr>
<tr>
<td>KDIGO (2012)</td>
<td>1–1.5 g/kg, up to 1.7 g/kg</td>
</tr>
</tbody>
</table>

*Note: Protein intake should be adjusted according to catabolic rate, renal function, and dialysis losses.*

*Avoid restriction of protein intake with the aim of preventing or delaying initiation of RRT.*
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Back to First Case

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- Sinogram: Duodenal stump leak/fistula
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### Volume & Micronutrients

- **Labs:**
  - 131
  - 96
  - 2.9
  - 4.3
  - 18
  - 67
  - 83

  **Phos** 4.8, **Mg** 2.3

- **Weight** 70 kg (dry 63 kg)
- **PE:** Signs of edema
- **Urine output:** nil
Volume and Sodium

• Hyponatremia in CKD
  – Consider volume overload
    • Exception: GI losses (fistula, ostomy)
  – Pair sodium restriction with volume restriction
    • Limit Na from all sources
Potassium, Phosphorus, Magnesium

- Interpret levels in context of replacement and timing of dialysis
- Composition and adjustments in concert with Nephrology colleagues
Two days later, patient becomes hypotensive, transfers to ICU. Fluids, broad-spectrum antibiotics, pressors are initiated. Weight is up to 75 kg. Nephrology sees patient and recommends switching to continuous veno-venous hemofiltration (CVVH).

How does this change your PN prescription?
Question #3

Daily calorie gain from contemporary CVVH fluids, specifically ACD-A solution, may total up to:

a) 500 kcal
b) 1200 kcal
c) Zero – pretty sure we don’t need to consider any energy gain
Venous access

Pre-filter Replacement Fluid

Dialysate

Post-filter Replacement Fluid

Effluent

ACD-A

Venous return

CVVH: Continuous Veno-Venous Hemofiltration

CVVHD: Continuous Veno-Venous Hemodialysis

CVVHDF: Continuous Veno-Venous Hemodiafiltration
CRRT: Two important variables

• Anticoagulation: ACD-A for regional anticoagulation
  – 2.45% dextrose, 2.2% citrate
  – high infusion rate

• Type of replacement fluids used
  – CVVH or CVVHDF
  – Dextrose content (0-110 mg/dl)
CVVH: Continuous Veno-Venous Hemofiltration

Venous access

Pre-filter Replacement Fluid

Dextrose 2.45% Citrate 2.2%

ACD-A

Effluent

Glucose removal

Post-filter Replacement Fluid

Dextrose 0 - 110 mg/dl

Venous return
Quantifying energy gain with CVVH

• Single-center, prospective observational study
• Aim: Quantify delivery of citrate and glucose from CVVH fluids
• 10 adult patients
• Study samples:
  – Pre-filter and post-filter
  – Each port: 4 samples, 10 minutes apart x 2 consecutive days
Measuring calorie sources in the CVVH circuit

Pre-filter Replacement Fluid

Replacement fluids: Dextrose 110 mg/dl

Post-filter Replacement Fluid

Pre-filter sample

ACD-A

Effluent

Post-filter sample
Day 1 vs. Day 2 (n = 8)

**Glucose**
- Prefilter: 11%
- Postfilter: 7%

**Citrate**
- Prefilter: 10%
- Postfilter: 11%

Slide courtesy: A. Nei
Glucose and citrate delivery

<table>
<thead>
<tr>
<th>Macronutrient</th>
<th>Delivery (mg/min)</th>
<th>Energy Gained (kcal/d)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose</td>
<td>55±5</td>
<td>299±27</td>
</tr>
<tr>
<td>Citrate</td>
<td>57±3</td>
<td>200±8</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>502±33</td>
</tr>
</tbody>
</table>

*Assuming no circuit downtime

CVVH with ACD-A for anticoagulation is a significant source of calories; ACD-A at 300 ml/h = 500 kcal/day

Slide courtesy: A. Nei
Question #3

Daily calorie gain from contemporary CVVH fluids, specifically ACD-A solution, may total up to:

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Our patient’s CRRT prescription

- CVVH
- Replacement fluid: Phoxillum… **Dextrose-free**
- Total hemofiltration (effluent) rate: 1800 ml/hr
  - 100 mg/dl (??) x 1.8 L/h = 1.8 g/h
  - 1.8 g/h x 24 h = 43 g/d
  - Glucose loss estimate: 150 kcal/day?
- Anticoagulation: ACD-A at 300 ml/h
  - Gain: ~500 kcal/day
- Net calorie gain estimate: 350 kcal/day
Take-home assignment

1. What type of CRRT modality is employed at my institution?
2. If CVVH or CVVHDF, what type of replacement fluids are used?
3. Anticoagulation used?
CRRT type

CVVH CVVHDF

CVVHD

ACD-A for anticoagulation?

Yes

Calorie (citrate/dextrose) GAIN

No

No effect

Replacement fluids dextrose free?

Yes

Calorie (glucose) LOSS

No

Minimal effect
PN prescription for CRRT

• Volume: Minimal

• Na, K, Ca, Phos, Mg
  – Zero all/minimal changes: “defer to Nephrology”
  – Phosphorus: +/- continuous infusion
  – Calcium: continuous infusion + standing orders for replacement: potassium, magnesium

• Watch hemodynamics

• Prolonged CRRT: Assess selenium, copper
  (Ben-Hamouda et al. Nutrition 2017)
Conclusion

• Conservative calorie provision with awareness of potential for calorie gain/loss with CRRT
• Don’t skimp on the protein. Avoid restricting in an effort to limit dialysis.
• Special considerations exist for electrolytes; remember to address sodium.
• Work in collaboration with Nephrology
Nutrition Support for ICU Patients: Chronic Kidney Disease

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CRRT Modalities*

• **CVVH** or **CVVHF** – Continuous veno-venous hemofiltration
  – Convection (requires replacement fluids)

• **CVVHD** - Continuous veno-venous hemodialysis
  – Diffusion

• **CVVHDF** – continuous veno-venous hemodiafiltration
  – Convection (requires replacement fluids) and diffusion

*“VV” may be AV (arteriovenous), i.e., CAVH, CAVHD, CAVHDF*
Calorie sources in the CVVH circuit

Glucose uptake = $(\text{Flow}_{\text{post}} \cdot [G]_{\text{post}}) - (\text{Flow}_{\text{pre}} \cdot [G]_{\text{pre}})$

Citrate uptake = $[(\text{Flow}_{\text{post}} \cdot (1-Hct_{\text{post}}) \cdot [C]_{\text{post}}) - ([\text{Flow}_{\text{pre}} \cdot 1-Hct_{\text{pre}}] \cdot [C]_{\text{pre}})]$

$\text{Flow}_{\text{post}} = \text{Flow}_{\text{pre}} + \text{replacement} - \text{effluent}$
## Replacement Fluids

<table>
<thead>
<tr>
<th></th>
<th>Ca(^{2+}) mEq/L</th>
<th>HCO(_3^-) mEq/L</th>
<th>K(^+) mEq/L</th>
<th>Mg(^{2+}) mEq/L</th>
<th>Na(^+) mEq/L</th>
<th>HPO(_4^{2-}) mmol/L</th>
<th>Cl(^-) mEq/L</th>
<th>Lactate mEq/L</th>
<th>Dextrose mg/dL</th>
<th>Osmolarity mOsm/L</th>
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<tr>
<td><strong>PRISMASOL</strong></td>
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<td></td>
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<tr>
<td>BGK0/2.5</td>
<td>2.5</td>
<td>32</td>
<td>0</td>
<td>1.5</td>
<td>140</td>
<td>0</td>
<td>109.0</td>
<td>3.0</td>
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<td>292</td>
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<td>BGK4/2.5</td>
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<td>4.0</td>
<td>1.5</td>
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<td>0</td>
<td>113.0</td>
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<td>1.0</td>
<td>140</td>
<td>0</td>
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<td>300</td>
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<td>BGK2/3.5</td>
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<td>2.0</td>
<td>1.0</td>
<td>140</td>
<td>0</td>
<td>111.5</td>
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<td>100</td>
<td>296</td>
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<td>140</td>
<td>0</td>
<td>108.0</td>
<td>3.0</td>
<td>100</td>
<td>291</td>
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<tr>
<td>B22GK4/0</td>
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<td>4.0</td>
<td>1.5</td>
<td>140</td>
<td>0</td>
<td>120.5</td>
<td>3.0</td>
<td>100</td>
<td>296</td>
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<tr>
<td>BGK4/0/1.2</td>
<td>0</td>
<td>32</td>
<td>4.0</td>
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<td>0</td>
<td>110.2</td>
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<tr>
<td>BK0/0/1.2</td>
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<td>32</td>
<td>0</td>
<td>1.2</td>
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<td>106.2</td>
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<td><strong>PHOXILLUM</strong></td>
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</tr>
</tbody>
</table>

Ca\(^{2+}\) = calcium, HCO\(_3^-\) = bicarbonate, K\(^+\) = potassium, Mg\(^{2+}\) = magnesium, Na\(^+\) = sodium, HPO\(_4^{2-}\) = phosphate, Cl\(^-\) = chloride; osmolarity is estimated.

Prescribing information. Gambro Renal Products, Daytona Beach, FL.
http://www.accessdata.fda.gov/drugsatfda_docs/label/2015/207026s000lbl.pdf
Abbreviations

• **ACD-A**: Acid-citrate dextrose, formula A anticoagulant solution
• **AKI**: acute kidney injury
• **CKD**: chronic kidney disease
• **CRRT**: continuous renal replacement therapy
• **GFR**: glomerular filtration rate
• **IHD**: intermittent hemodialysis
• **PN**: Parenteral nutrition
• **RCA**: Regional citrate anticoagulation
• **RRT**: renal replacement therapy
CRRT modalities

• **Convection or hemofiltration**: CVVH
  – \( H \) = hemofiltration
  – Molecules (small and medium) move via pressure gradient
  – Requires replacement fluid, pre- or post-filter or both

• **Diffusion or hemodialysis**: CVVHD
  – \( HD \) = hemodialysis
  – Small molecules removed down a concentration gradient
  – Dialysate fluid is used
  – No replacement fluid

• **Convection and diffusion**: CVVHDF
  – \( HDF \) = hemodiafiltration
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