Urine Electrolytes

ACOI Hospitalist 2016
Disclosures

Nothing to declare
<table>
<thead>
<tr>
<th>Electrolyte</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na⁺</td>
<td>To assess volume status</td>
</tr>
<tr>
<td></td>
<td>Differential diagnosis of hyponatremia</td>
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<tr>
<td></td>
<td>Differential diagnosis of AKI</td>
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<tr>
<td></td>
<td>To assess salt intake in patients with hypertension</td>
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<tr>
<td></td>
<td>To evaluate calcium and uric acid excretion in stone-formers</td>
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<tr>
<td></td>
<td>To calculate electrolyte-free-water clearance</td>
</tr>
<tr>
<td>Cl⁻</td>
<td>Differential diagnosis of metabolic alkalosis</td>
</tr>
<tr>
<td>K⁺</td>
<td>Differential diagnosis of hypokalemia</td>
</tr>
<tr>
<td></td>
<td>To calculate electrolyte-free-water reabsorption</td>
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<tr>
<td></td>
<td>To calculate transtubular K⁺ gradient</td>
</tr>
<tr>
<td>Creatinine</td>
<td>To calculate fractional excretion of Na⁺ and renal failure index</td>
</tr>
<tr>
<td></td>
<td>To assess the adequacy of 24-h urine collection</td>
</tr>
<tr>
<td>Urine osmolality</td>
<td>Differential diagnosis of hyponatremia</td>
</tr>
<tr>
<td></td>
<td>Differential diagnosis of polyuria</td>
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<tr>
<td></td>
<td>Differential diagnosis of AKI</td>
</tr>
<tr>
<td>Urine anion gap</td>
<td>To distinguish primarily hyperchloremic metabolic acidosis</td>
</tr>
<tr>
<td></td>
<td>between distal renal tubular acidosis and diarrhea</td>
</tr>
<tr>
<td>Electrolyte-free-water clearance</td>
<td>To assess the amount of water excretion (without solutes)</td>
</tr>
<tr>
<td></td>
<td>only in the management of hypo- and hypernatremia</td>
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</tbody>
</table>

AKI acute kidney injury
Case 1

75 yo gentleman with complex PMH (AF, MI, CAD, DM II, Stage 3 CKD) admitted for CAP

Improved on appropriate treatment including exoxaparin and was slated for DC in AM

Developed acute abdominal pain and hypotension

On exam he had a large abdominal wall mass on L side
Case 1

His Hg went from 11 to 5
His creatinine went from 1.5 to 3.1 and urine output was < 0.5 ml/kg for > 12 hrs
CT scan (no contrast) showed a large abdominal wall mass consistent with rectus sheath hematoma
With IVF and pRBCs his BP normalized but he remained oliguric despite loop diuretics
Case 1

We were asked to see him for AKI (BUN/Creatinine 50/4.1), hypoNa (126) and hyperK (7.1)

Urine - +1 protein, 0-5 RBCs, 5-10 RTEs and a few granular casts

UNa 60  UCre 40  UUN 100

FeNa 4.88%  FeUrea 20.5%

How can the above be used for diagnosis?
Urine Studies in AKI

Urine Na and urine urea have been used to differentiate pre-renal failure from AKI (ATN)

UNa < 20 = pre-renal  UNa > 40 = renal (doesn’t tell the whole story) (urine volume and concentration)

FeNa < 1% pre-renal  FeNa > 3% renal – better

Is the kidney holding onto Na because of pre-renal state?
\[
FE_{Na} (\%) = \frac{\text{Quantity of Na}^+ \text{ excreted}}{\text{Quantity of Na}^+ \text{ filtered}} = \frac{U_{Na} + P_{Cr}}{P_{Na} + U_{Cr}} \times 100.
\]
Urine Studies in AKI

FeUrea is useful in times that diuretics are used
Pre-renal FeUrea < 35%
Renal FeUrea – 50-65%

More specific but insensitive
Urine Studies in AKI - Problems

Pre-renal states with high FeNa
CKD, diuretics, glucosuria, vomiting, ketonuria

AKI/Renal with low FeNa
GN, AIN, Pigment nephropathy, sepsis, contrast, obstruction, AKI in CHF and cirrhosis

Creatinine not steady state with AKI
Urine Studies in AKI - Problems

AKI diagnosis is based on evaluation of all parameters. Clinical trumps labs
Evaluation for volume responsiveness
  Tilt, H&P
  Pulse pressure variation
  Passive straight leg raise
Exam in nephrology – wet vs. not wet
  not wet gets fluids until better or wet
Case 1

BUN/Cre  50/4.1, hypoNa (126) and hyperK (7.1)
UNa 60    UCre 40    UUN 100
FeNa 4.88%    FeUrea 20.5%

On exam – not wet. Given isotonic fluid with no response. Treated with RRT
Case 2

An frail elderly woman with depression on an SSRI presents with weakness. She appears euvolemic. No NSAIDs. No diuretics. Her labs are as follows:

Na 114       K 4.0  Cl 80  HCO3 24
BUN 6       CRE 0.5  UA 3.1
UOSM 130  UNa 22   FeNa 0.8%
Hyponatraemia

Is the patient dehydrated?

Yes

Is urinary Na > 20 mmol/L?

Yes

Renal Na⁺ loss
• Addison's
• Renal failure
• Diuretic excess
• Osmolar diuresis

No

Loss elsewhere
• Diarrhoea
• Vomiting
• Fistulae
• Burns
• Small-bowel obstruction
• Trauma
• CF
• Heat exposure

No

Urine osmolality >500 mmol/kg?

Yes

• Nephrotic synd.
• Cardiac failure
• Cirrhosis
• Renal failure

No

• Inappropriate ADH

No

• Water overload
• Severe hypothyroidism
• Glucocorticoid insufficiency

No

Is the patient oedematous?

Yes

No
Approach to Hyponatremia

Urine Na and FeNa are low (<20 and <1%) in hypervolemic and hypovolemic hyponatremia (non renal Na loss)

Urine Na and FeNa are high (>20 and 1%) in euvolemic and hypovolemic hyponatremia due to renal losses

Low BUN and Uric Acid – euvolemic or cirrhosis

Isotonic saline infusion – Gold Standard
If PNa↓, Uosm should be <100

If not, non osmolar ADH release
e.g. ECF volume ↓, CHF, SIADH
Dilute Urine (Uosm < 300) and HypoNa

Psychogenic polydipsia – intake overwhelms the capacity of the kidney to excrete H2O

Beer potomania – low solute intake impairs the ability of the kidney to excrete H2O (VA)

Tea and toast - low solute intake impairs the ability of the kidney to excrete H2O (LOL)

Important category – chronic and could rapidly correct. High risk for ODS
Case 2

Na 114    K 4.0    Cl 80    HCO3 24
BUN 6    CRE 0.5    UA 3.1
UOSM 130    UNa 22    FeNa 0.8%

She was treated with H2O restriction, solute (food) and limited isotonic saline with goal correction of 6 meq/day
Case 3

65 yo AA man with history of longstanding hypertension (well controlled) presents with weakness, swelling and dyspnea on exertion.

PMH/PSH/Social Hx – not significant

Meds – Amlodipine 5 daily
Case 3

Labs: Hg 8.2  WBC 4.2  PLT 122
Na 138  K 2.7  Cl 115  HCO3 15  Ca 8.2  Alb 3.2
BUN 20  Cre 1.4  Glucose 84  PO4 2.4
UA – pH 5  +1 protein  +2 glucose
Ualb 80mg/dl  UCre 105 mg/dl  UPro 420 mg/dl
UAC 0.760  UPC 4.0  UAPR 19%
<table>
<thead>
<tr>
<th>UPC  MG/MG/DL</th>
<th>DIAGNOSIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;0.2</td>
<td>NRML OR VASCULAR DX</td>
</tr>
<tr>
<td>0.2 – 0.5</td>
<td>VASC/INTERSTIT/GN</td>
</tr>
<tr>
<td>0.5 – 1.0</td>
<td>INTERSTIT/GN</td>
</tr>
<tr>
<td>&gt; 1.0</td>
<td>GN/INTERSTIT</td>
</tr>
</tbody>
</table>
Protein-creatinine ratio to estimate protein excretion. The relation between total daily protein excretion and the total protein-to-creatinine ratio (mg/mg) determined on a random urine specimen. (Data from Ginsberg, JM, Chang, BS, Matarese, RA, Garella, S, N Engl J Med 1983; 309:1543.)
Urine albumin to protein ratio (UAPR)

The ratio of UAC to UPC can be helpful in localizing kidney disease

UAPR > 50% - glomerular
UAPR < 40% - tubular
UAPR < 25% - myeloma cast
Case 3

Labs: Hg 8.2  WBC 4.2  PLT 122
UA – pH 5  +1 protein  +2 glucose
Ualb 80mg/dl  UCre 105 mg/dl  UPro 420 mg/dl
UAC 0.760  UPC 4.0  UAPR 19%

Large amount of non-albumin protein consistent with myeloma
Case 3

Na 138   K 2.7   Cl 115   HCO3 15   Ca 8.2   Alb 3.2
BUN 20   Cre 1.4   Glucose 84   PO4 2.4
UA – pH 5   +1 protein   +2 glucose
UNa 30   UK 28   UCl 80
Urine Anion Gap

HCO3 is either resorbed (prox) or regenerated (distal)

To regenerate HCO3 - NH4 is formed distally

In an acidic urine Na+K+NH4 = Cl

NH4 can not be measured therefore

Cl > Na+K if NH4 is present  NL DISTAL FX

If Cl < or = Na+K then distal urinary acidification is impaired (UAG abnormal)
Urine Anion Gap (UAG) = \((U_{Na^+} + U_{K^+}) - U_{Cl^-}\)

- \(NH_4^+\) is the primary unmeasured cation which is not balanced by anions.
- UAG as indirect assay for renal NH4+ excretion
Urine Anion Gap

The urine anion gap is useful in distinguishing disorders with normal ammonium excretion from those with abnormal excretion.

**Normal UAG** – Proximal RTA or non renal acidosis (diarrhea etc.) (Cl > Na + K)

**Abnormal UAG** – CKD (lack of NH4 production), distal RTA Type I and IV or aldosterone deficiency) (Cl ≤ Na + K)
Hyperchloremic Metabolic Acidosis
Normal Urine NH4 (Cl > Na + K)

this is due to HCO3 loss with normal distal tubular function

**GI** - loss of HCO3 due to diarrhea, urinary diversion or pancreatic fistulae

**Renal** - proximal RTA (type 2) leads to renal HCO3 loss with normal distal regeneration. May be associated with other proximal defects (Fanconi’s), hypergammaglobulinemia, drugs (toluene, toperimate, zonisamide, tenofovir, azetazolamide) or multiple myeloma
Hyperchloremic Metabolic Acidosis

Abnormal NH$_4$

**Classic Distal** - a defect in the proton pump leads to a U pH > 5.5 and acidosis (Type 1) (ampho B, HyperPTH, Sjogren’s, medullary sponge kidney)

**Hyperkalemic Distal** - a defect in the aldo sensitive collecting duct leads to acidosis and hyperkalemia with preserved renal acidification (Type 4) (obstruction, aldo resistance)

**NH$_3$ Defect** - CKD leads to abnormal NH$_3$ production with preserved urinary acidification (GFR < 30)
<table>
<thead>
<tr>
<th>Defect</th>
<th>U pH</th>
<th>UAG</th>
<th>K (serum)</th>
<th>GFR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proximal RTA (II)</td>
<td>&lt; 5</td>
<td>NI</td>
<td>Low</td>
<td>nl</td>
</tr>
<tr>
<td>Distal RTA (I)</td>
<td>&gt; 5</td>
<td>Low</td>
<td>Low</td>
<td>NI</td>
</tr>
<tr>
<td>Distal RTA (IV)</td>
<td>&lt; 5</td>
<td>Low</td>
<td>High</td>
<td>NI to low</td>
</tr>
<tr>
<td>CKD</td>
<td>&lt; 5</td>
<td>Low</td>
<td>NI to high</td>
<td>&lt; 30</td>
</tr>
</tbody>
</table>
Case 3

Na 138   K 2.7   Cl 115   HCO3 15   Ca 8.2   Alb 3.2
BUN 20   Cre 1.4   Glucose 84   PO4 2.4
UA – pH 5   +1 protein   +2 glucose
UNa 30   UK 28   UCl 80

UAG - Cl > Na + Cl (normal NH4 excetion) = normal distal tubular . Defect is proximal
Glucosuria + proximal defect – Fanconi’s
<table>
<thead>
<tr>
<th>Condition</th>
<th>Electrolyte (mEq/L)</th>
<th>Diagnostic possibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypovolemia</td>
<td>Na⁺ (0–20)</td>
<td>Extrarenal loss of Na⁺</td>
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<tr>
<td></td>
<td>Na⁺ (&gt;20)</td>
<td>Renal salt wasting</td>
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<td></td>
<td></td>
<td>Adrenal insufficiency</td>
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<td></td>
<td></td>
<td>Diuretic use or osmotic diuresis</td>
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<tr>
<td>Acute kidney injury</td>
<td>Na⁺ (0–20)</td>
<td>Prerenal azotemia</td>
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<tr>
<td></td>
<td>Na⁺ (&gt;20)</td>
<td>Acute tubular necrosis (ATN)</td>
</tr>
<tr>
<td></td>
<td>FE₉¹Na (≤1 %)</td>
<td>Prerenal azotemia</td>
</tr>
<tr>
<td></td>
<td>FE₉¹Na (&gt;2 %)</td>
<td>ATN due to contrast agent</td>
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<tr>
<td></td>
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<td>Rhabdomyolysis</td>
</tr>
<tr>
<td>Hyponatremia</td>
<td>Na⁺ (0–20)</td>
<td>ATN</td>
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<tr>
<td></td>
<td>Na⁺ (&gt;20)</td>
<td>Diuretic use</td>
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<td></td>
<td></td>
<td>Hypovolemia</td>
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<td>Edematous disorders</td>
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<td></td>
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<td>Water intoxication</td>
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<td></td>
<td></td>
<td>SIADH</td>
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<td>Cerebral salt wasting (CSW)</td>
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<td></td>
<td></td>
<td>Adrenal insufficiency</td>
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<tr>
<td></td>
<td>↑FEₙ¹UA (&gt;10 %)</td>
<td>SIADH and CSW</td>
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<tr>
<td></td>
<td>↑FEₙ¹P04 (&gt;20 %)</td>
<td>CSW</td>
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<tr>
<td>Metabolic alkalosis</td>
<td>Cl⁻ (0–10)</td>
<td>Cl⁻-responsive alkalosis</td>
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<tr>
<td></td>
<td>Cl⁻ (&gt;20)</td>
<td>Cl⁻-resistant alkalosis</td>
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<tr>
<td>Hypokalemia</td>
<td>K⁺ (0–10)</td>
<td>Extrarenal loss of K⁺</td>
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<td>K⁺ (&gt;20)</td>
<td>Renal loss of K⁺</td>
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<tr>
<td>TTKG</td>
<td>Normal</td>
<td>6–8</td>
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<tr>
<td></td>
<td>Hyperkalemia</td>
<td>&lt;5</td>
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<tr>
<td></td>
<td>Hypokalemia</td>
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<tr>
<td></td>
<td>U₉¹AG</td>
<td>Positive (from 0 to +50)</td>
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<tr>
<td></td>
<td></td>
<td>Distal renal tubular acidosis</td>
</tr>
<tr>
<td></td>
<td>Negative (from 0 to −50)</td>
<td>Diarrhea</td>
</tr>
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