Nephrology Board Simulation

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Objectives

• The practice taking the Internal Medicine Board exam using board-related Nephrology questions

• To review key educational points in determining the correct responses to board-related Nephrology questions.
Case 1

A 26-year old male presents with complaints of lower extremity edema for the past week. He has been using ibuprofen 800 mg 3x/day for one month for a shoulder injury.

Exam is significant for a blood pressure of 130/90 and 3+ lower extremity edema

Urinalysis: 4+ protein, no blood
24-hour urine protein: 10.8 grams, no hematuria
Serum creatinine: 0.9 mg/dL (eGFR >60cc/min)
Question 1: The most likely disorder causing this clinical picture is:

A. Human Immunodeficiency Virus (HIV) nephropathy

B. Focal segmental glomerulosclerosis

C. Acute tubular necrosis

D. Minimal change disease
Answer 1. D (Minimal Change Disease)

**Minimal Change Disease (MCD)**

- Nephrotic syndrome without hematuria
  - Preserved renal function most commonly
  - 15% of adults may present with ATN due to volume depletion
- Steroids first-line therapy
Answer 1. D (Minimal Change Disease)

5 ways glomerular disease can present:

1. Asymptomatic hematuria
2. Acute nephritis
3. Rapidly progressive glomerulonephritis
4. Chronic nephritis
5. **Nephrotic syndrome**: >3gm proteinuria, edema, low albumin, hyperlipidemia
Answer 1. D (Minimal Change Disease)

- **Secondary causes of minimal change disease**
  - **NSAID’s**
    - Other medications include Gold, Lithium
  - Blood tumors: *Hodgkin’s*, leukemias
  - Insect bites, other antigenic stimuli
- **Treat underlying illness or remove offending agents**
Answer 1. D (Minimal Change Disease)

Treatment of Primary Minimal Change
1. High dose steroids – 8-12 weeks
2. Oral cyclophosphamide
3. Oral cyclosporine

Responses to Treatment
1. Steroid responsive
2. Steroid dependent
3. Steroid resistant
Answer 1. Other Options

A. HIV Associated Nephropathy (HIVAN)
   - Nephrotic syndrome with decreased kidney function
   - Collapsing FSGS is the classic lesion
   - Echogenic kidneys on US
   - HAART mainstay of therapy
Answer 1. Other Options

B. Focal Segmental Glomerulosclerosis (FSGS)

– Nephrotic syndrome, bland urinary sediment, decreased kidney function
– Most common cause of nephrotic syndrome in adults, especially African Americans
– Secondary disease
  • Common end-point of glomerular injury
  • Hyperfiltration of remnant glomeruli
C. Acute Tubular Necrosis
- Acute kidney injury manifested by decreased kidney function
- Minimal proteinuria
- Ischemic, toxic most common causes
- Does not present with nephrotic syndrome
Case 2

A 26 year-old male presents with hematuria (i.e., tea-colored urine), arthralgias, and a heart murmur. The patient was recently discharged from military service, and he developed an upper respiratory infection 10 days ago.

Physical examination reveals a swollen and tender right wrist and left elbow, prominent cervical/submandibular nodes, 2/6 systolic ejection murmur, and 2+ edema.
Case 2 (cont.) Labs:

Urinalysis: SG 1.013;
No glucose;
pH 6.0;
3+ protein; large blood

Microscopy: 20 RBC/HPF; 3 to 5 RBC casts;
5 to 10 white blood cells/HPF.

Serologies: Low C3 level;
Creatinine 2.2 mg/dL,
Glucose 51 mg/dL;
Elevated rheumatoid factor;
FeNa 3.2%; positive cryoglobulins
Question 2: The most likely cause for this clinical scenario is:

A. Membranous glomerulonephritis

B. Wegener's granulomatosis

C. Poststrepococcal glomerulonephritis

D. Acute tubular necrosis

E. Fanconi's syndrome
Answer 2: C (Post-Streptococcal Glomerulonephritis)

5 ways glomerular disease can present:

1. Asymptomatic hematuria
2. Acute nephritis
3. Rapidly progressive glomerulonephritis
4. Chronic nephritis
5. Nephrotic syndrome: >3gm proteinuria, edema, low albumin, hyperlipidemia
Answer 2: C (Post-Streptococcal Glomerulonephritis)

Nephritic syndrome

• Glomerular hematuria, tea-colored urine
• Hypertension
• Renal failure, often oliguric
• Proteinuria usually mild
• Mild edema
Answer 2: C (Post-Streptococcal Glomerulonephritis)

• *Post-Pharyngitic* Nephritis
  – Acute nephritis 10-14 days after a strep infection
    • Differentiation from IgA Nephropathy

• Pharyngitis or skin infections (impetigo)

• May require transient dialysis

• Self-limited course, may result in permanent kidney dysfunction

• If strep has been cleared, supportive treatment
Answer 2: C (Post-Streptococcal Glomerulonephritis)

- Culture if active infection (and treat)
- Serologies: ASO, DNase, anti-hyaluronic acid antibodies
- Low C3 level during the first week
- Elevated rheumatoid factor and circulating cryoglobulins
- Renal failure and hematuria resolve first
- Proteinuria can persist for months
Answer 2: C (Post-Streptococcal Glomerulonephritis)

Other Renal Diseases Associated with low C3 +/- low C4:

1. Membranoproliferative glomerulonephritis (MPGN)
2. Cryoglobulinemia
3. Systemic lupus erythematosus
4. Subacute bacterial endocarditis
   • (Occasionally hemolytic uremic syndrome- thrombotic thrombocytopenic purpura, severe malnutrition, and hepatic failure)
Answer 2: Other Options

A. Membranous GN

- Nephrotic syndrome +/- kidney dysfunction
- A/w DVT’s, renal vein thrombosis
- Anti-phospholipase A2 receptor for idiopathic
- Does not present with acute nephritic syndrome
- Secondary causes:
  - Solid organ tumors - SLE
  - Drugs: Penicillamine, gold - Hepatitis B
Answer 2: Other Options

B. Wegener’s Granulomatosis

- Pulmonary-renal syndrome
- ANCA associated vasculitis
- Rapidly progressive GN
  - Crescents common
- Systemic symptoms of vasculitis common
- Life-threatening illness requiring prompt diagnosis and treatment
- GN: Steroids, cyclophosphamide, +/- pheresis
Answer 2: Other Options

E. Fanconi Syndrome

- Not associated with renal dysfunction
- Proximal renal tubular acidosis (RTA)
  - Hyperchloremic metabolic acidosis
  - Glycosuria, phosphaturia, amino acidouria
  - Mild proteinuria
Case 3

A 36 year old female with recurrent kidney stones presents for further evaluation. Her first kidney stone was approximately 15 years ago, and since, she notes she has passed approximately 50 stones.

She has a strong family history of kidney stones in her father and brother, but no kidney failure. Type of stone is unknown. She was told to restrict her calcium intake for the past few years.
## Case 3

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
<th>Reference Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creatinine</td>
<td>0.80</td>
<td>7-1.4 mg/dL</td>
</tr>
<tr>
<td>Sodium</td>
<td>138</td>
<td>135-146 mmol/L</td>
</tr>
<tr>
<td>CO2</td>
<td>24</td>
<td>24-32 mmol/L</td>
</tr>
<tr>
<td>Calcium</td>
<td>10.7</td>
<td>8.5-10.5 mg/dL</td>
</tr>
<tr>
<td>PTH</td>
<td>86</td>
<td>10-60 pg/mL</td>
</tr>
<tr>
<td>Phosphorous</td>
<td>2.8</td>
<td>2.5-4.5 mg/dL</td>
</tr>
<tr>
<td>Ca UR 24 hr</td>
<td>401.7</td>
<td>100-300 mg/24 hr</td>
</tr>
<tr>
<td>Citric 24 hr</td>
<td>704</td>
<td>320-940 mg/24hrs</td>
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<tr>
<td>Oxal 24 hour</td>
<td>91</td>
<td>10-50 mg/24h</td>
</tr>
<tr>
<td>Sodium 24 hr</td>
<td>315</td>
<td>40-220 mmol/24h</td>
</tr>
<tr>
<td>Uric 24 hr</td>
<td>1010.4</td>
<td>250-750 mg/24hr</td>
</tr>
<tr>
<td>Volume</td>
<td>4141</td>
<td>mL</td>
</tr>
</tbody>
</table>
Question 3: Which of the following is an inhibitor of calcium stone formation?

A. High urinary oxalate concentration
B. High urinary citrate concentration
C. High urinary sodium concentration
D. High dietary protein intake
E. High dietary purine intake
Answer 3: B. High Urinary Citrate Concentration

- Urinary citrate binds urinary calcium
  - Non-dissociable but soluble complex
  - Prevents calcium from complexing with oxalate
- Examples of diagnoses associated with low urinary citrate
  - Idiopathic hypocitraturia
  - RTA (distal)
  - Medullary sponge kidney
  - Metabolic acidosis: malabsorption, ureteral diversion
Answer 3: Other Options

Risk Factors for Calcium Nephrolithiasis:

<table>
<thead>
<tr>
<th>Low urine volume</th>
<th>Hyperoxaluria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypercalciuria</td>
<td>-Calcium restriction</td>
</tr>
<tr>
<td>-Idiopathic</td>
<td>-Malabsorption</td>
</tr>
<tr>
<td>-High sodium intake</td>
<td></td>
</tr>
<tr>
<td>-Loop diuretics</td>
<td>Hyperuricosuria</td>
</tr>
<tr>
<td>Hyperparathyroidism</td>
<td>Urine pH</td>
</tr>
<tr>
<td>Hypocitraturia</td>
<td>-Depends on stone type</td>
</tr>
<tr>
<td>Renal Tubular Acidosis</td>
<td>-Protein loading</td>
</tr>
</tbody>
</table>
Answer 3: Other Options

Common management of all kidney stones to decrease recurrence:

• Increasing urine volume to over 2 L per day
• 2000mg daily sodium restriction
• DO NOT restrict calcium intake
• Limit high animal fat diets
Question 4: Renal manifestations of HIV infection include which of the following?

A. Hyponatremia
B. Tubuloreticular inclusions
C. Focal segmental glomerular sclerosis
D. Acute tubular necrosis
E. All the above
Answer 4: E (all the above)

A. Hyponatremia

- Seen in 60% of HIV patients during their disease
  - Volume depletion with up-regulation of AVP
  - SIADH with pulmonary and intracranial disease
    - Toxoplasmosis
    - Tuberculosis
    - Pneumocystosis
B. Tubuloreticular Inclusions
• Associated with IFN up-regulation
• Also can be seen in lupus nephritis and after treatment of HCV with IFN
• Seen on biopsy

C. Focal Segmental Glomerulosclerosis
• Previously discussed
Answer 4: E (all the above)

D. Acute Tubular Necrosis

- Acute renal failure in HIV:
  - ATN: medications, hypovolemia, shock
  - AIN: medications, infection
  - HUS/TTP
  - Crystal-induced:
    acyclovir, indinavir, sulfa drugs

Indinavir Crystals
Case 5

A 65 year-old male with BPH presents for follow-up 5 days into treatment of a urinary tract infection with trimethoprim-sulfamethoxazole. His symptoms have resolved. Temperature 37.5 C; the remainder of the physical exam is normal. Lab work obtained shows:

<table>
<thead>
<tr>
<th></th>
<th>2 weeks prior</th>
<th>Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUN</td>
<td>12 mg/dl</td>
<td>12 mg/dl</td>
</tr>
<tr>
<td>Creatinine</td>
<td>1.4 mg/dl</td>
<td>2.0 mg/dl</td>
</tr>
</tbody>
</table>
CASE 5 (Cont’d)

Urinalysis:

S.G. 1.010
Heme: neg.
Protein: neg.
Leukocyte esterase: negative
No casts
Question 5: In the above patient, the most likely reason for the creatinine increase to 2.0 mg/dL is:

A. Acute interstitial nephritis
B. Acute pyelonephritis
C. Obstructive uropathy
D. Reduced creatinine excretion
E. Acute tubular necrosis
Answer 5: D: Reduced Creatinine Excretion

- Properties of serum creatinine excretion
  - Filtered by the glomerulus
  - Excreted by the proximal tubule
  - Slightly over-estimates true GFR

- Certain organic cations (e.g. Trimethoprim, cimetidine) competitively inhibit creatinine secretion
  - Sometimes used to more accurately reflect the true GFR (cimetidine GFR)
Solute Clearance

- Endogenous Production
- Exogenous Addition

Serum Concentration

- Glomerular Filtration
- Tubular Secretion
- Tubular Concentration

- Tubular Reabsorption
- Urinary Excretion
Solute Clearance

**Inulin**

- **Endogenous Production**
- **Exogenous Addition**

**Serum Concentration**

- Glomerular Filtration
- Tubular Secretion
- Tubular concentration
- Urinary excretion

- Tubular Reabsorption
Solute Clearance
Creatinine: Overestimation

Endogenous Production

Exogenous Addition

Serum Concentration

Glomerular Filtration

Tubular Concentration

Urinary Excretion

Tubular Secretion

Tubular Reabsorption

Blocked by trimethoprim
Answer 5: Other Options

A. Acute Interstitial Nephritis
   - Associated with sulfa use
   - Sterile pyuria, WBC casts on urine
   - Can be associated with fever or rash

B. Acute pyelonephritis
   - Infection has cleared without clinical pyelonephritis
   - Not associated with AKI
Answer 5: Other options

C. Obstructive Uropathy
- Sulfa crystals can lead to obstruction, hematuria
- Early obstruction may appear like pre-renal azotemia, and have a low FeNa
- Stable BUN suggests against true ARF

E. Acute Tubular Necrosis
- Stable BUN, no urinary evidence of ATN
Case 6

A 65 year old male presents to the office with low back pain, generalized weakness and fatigue of 4 months duration. He has no significant past medical history.

BP: 140/92
Conjunctival and mucosal pallor
No edema
Point tenderness over T12-S1
Case 6

- Hgb: 9 g/dL
- 24 hr urine protein 1.95 gm
- Serum creatinine 4.7 mg/dL
Case 6

The patient undergoes a kidney biopsy which demonstrates dilated tubules filled with PAS-negative eosinophilic material. The affected tubules are surrounded by polymorphonuclear leukocytes, monocytes and giant cells.

Glomeruli are relatively unremarkable.
Question 6: Which of the following urinalyses would most likely correspond to this patient’s disease?

A. pH 5; heme neg; protein neg; SSA 3+
B. pH 5; heme neg; protein 3+; SSA neg
C. pH 5; heme neg; protein 3+; SSA 3+
D. pH 5; heme neg; protein neg; SSA neg
E. pH 5; heme pos; protein 3+; SSA neg
Answer 6: A. Protein neg; SSA 3+
Cast Nephropathy

Teaching Points on urinary protein assessment

• Urine dipstick detects only albumin
  – Not light chains
• SSA (Sulfasalicylic Acid)
  – Detects all proteins
• Early paraproteinemia with light chain proteinuria
  – Dipstick protein negative, SSA positive
• Glomerular damage leads to non-selective proteinuria: Albuminuria present (answer C)
Multiple Myeloma and Cast Nephropathy

- Older gentleman with anemia, low back pain and renal failure – think multiple myeloma
- Renal dysfunction (SCr >2mg/dL) is the presenting feature in 55% of MM
AKI in Setting of Paraproteinemia:

- Myeloma kidney (*Cast nephropathy*) ~80%
  - Tubular obstruction with paraproteins
  - Heavy proteinuria with renal failure
- Amyloidosis ~10%
  - Glomerular, tubular and vascular deposition of proteins in beta-pleated sheets
  - Heavy proteinuria with renal failure
Answer 6

AKI in setting of paraproteinemia:

- Light chain deposition disease (LCDD) ~5-10%
- Heavy chain deposition disease (HCDD)
  - Tubular deposits
  - Renal failure more prominent than proteinuria
- Interstitial plasma cell infiltration
- Metabolic derangements
  - Hypercalcemia, hyperuricemia
Answer 6

- Proximal tubular dysfunction and the Fanconi syndrome may precede overt multiple myeloma.

Any adult with new onset proximal RTA should have light chain disorder ruled out.
Case 7

A 28 yr-old female with 18 yr history of diabetes mellitus is seen at 12 weeks gestation of her first pregnancy. She is taking enalapril 5 mg per day for hypertension and diabetic nephropathy. Her blood pressure is 160/100. The remainder of the exam is normal.

Laboratory studies reveal:
- Hgb 12 g/dl
- Hgb A1C 10%
- Cr 0.8 mg/dl
- BUN 10 mg/dl
- U/A 1+ gluc
- 3+ protein
- 24 hr excretion 1.2 gm
Question 7: Which of the following would you advise?

A. Increase enalapril to 10 mg per day
B. Replace enalapril with hydrochlorothiazide 12.5mg per day
C. Continue enalapril and add alpha-methyldopa 250 mg twice a day
D. Replace enalapril with alpha-methyldopa 250 mg twice a day
E. Continue enalapril and add amlodipine 5 mg per day
Answer 7: D. Replace enalapril with methyldopa

• Issue: Hypertension in pregnancy (BP>140/90)
  – Common Internal Medicine issue
  – Identify medications safe for use during pregnancy or when attempting to become pregnant
Answer 7: Hypertension in Pregnancy

• Angiotensin converting enzyme inhibitors
  – Cross the placenta
  – Angiotensin II important in the regulation of placental blood flow and normal fetal growth
  – Associated with fetal developmental abnormalities, in all trimesters
    • CV and CNS in first trimester
    • Renal, limb and others later
Answer 7: Hypertension in Pregnancy

**Safe Meds**

- Methyldopa
- Labetolol
- Long acting CCB’s
  - nifedipine best studied
- Hydralazine
- Thiazides considered safe if already on them
Answer 7: Hypertension in Pregnancy

Classifications of Hypertension in Pregnancy

1. Pre-existing hypertension
   Before 20 weeks gestation or lasting 12 weeks post-partum

2. Pre-eclampsia
   HTN after 20 weeks, edema, proteinuria

3. Gestation hypertension
   After 20 weeks gestation
Case 8

A 68 yo woman with a 20 year history of hypertension presents to you for hospital follow up. She presented to the ER with headache and blood pressure of 200/70. Creatinine was 1.6 mg/dL (stable for 3 yrs), renal US revealed 12 cm kidneys.

Medications: clonidine 0.1mg bid, atenolol 50mg daily, HCTZ 25mg daily, amlodipine 2.5mg daily

A renal artery duplex was suggestive of RAS.
She underwent renal artery angiography which revealed 55% stenosis on left, and 35% stenosis on right, with a markedly atheromatous aorta.

Lab studies reveal:

- TSH 1.5 mU/ml;
- Plasma renin activity 0.5 mg/L/H; plasma Aldosterone 10 ng/dl
- Urine dipstick protein 1+, Urinary protein:creatinine 0.6gm/gm
- Na+ 140; K+ 4.2; CO2 26; Creatinine 1.6 mg/dl
Question 8: What is the most likely cause of this patient’s hypertension?

A. Essential hypertension
B. Primary hyperaldosteronism
C. Glucocorticoid remediable hyperaldosteronism
D. Renal arterial stenosis
E. Pheochromocytoma
Answer 8: A. Essential Hypertension

• Essential Hypertension: Idiopathic, no identifiable cause

• To determine why this is the correct answer, we need to discuss why the other answers are incorrect
Answer 8

Secondary Hypertension:

Obstructive sleep apnea
Hyper/Hypo-Thyroidism
Contraceptives, Coarcation of aorta, Cushing’s
Renal artery stenosis, Renal disease
Aldosteronism
Pheochromocytoma
Answer 8: Other Options

B. Primary Hyperaldosteronism

- Elevated aldosterone with suppressed renin
- Hypokalemic with renal K wasting
- Metabolic alkalosis
- Elevated 24-hour urine aldosterone and K excretion
- Does not fit this clinical presentation
Answer 8: Other Options

C. Glucorticoid Remediable Aldosteronism (GRA)

- ACTH cross-over stimulation of aldosterone secretion
- Similar profile to primary hyperaldosteronism
  - Aldo/renin ratio not as high as primary hyperaldro
- Autosomal dominant, family history
- Young age onset
- Very rare
Answer 8: Other Options

D. Renal Artery Stenosis

• Renovascular hypertension:
  • Onset in women <30 years old (FMD) without family history
  • Onset >55 years old (AS)
  • Newly worsening hypertension
  • Resistant hypertension (failing 3 meds)
  • Abdominal bruises
Answer 8: Other Options

D. Renal Artery Stenosis

- Renin and aldosterone may be elevated
- “Significant” stenoses:
  - >70% unilaterally
  - >50% bilateral (*debatable numbers*)
- Essential hypertension with incidental RAS more common
  - Will not respond to revascularization
- Case: Long history of HTN and low-grade stenoses – unlikely renovascular hypertension
Answer 8: Other Options

- **Indications for intervention in RAS**
  1. FMD (balloon only)
  2. New resistant or sudden severe worsening of previously stable HTN
  3. Flash pulmonary edema (bilateral disease)
  4. Rapidly worsening renal function
  5. AKI after starting ACEI (>30% rise in SCR)
Answer 8: Other Options

• **Defining resistant HTN**
  
  • Refractory to 3 antihypertensive medications, including a diuretic
  
  • Make sure of three things:
    – The drugs are maximally dosed (amlodipine 2.5mg/day)
    – The dosing intervals are appropriate (clonidine bid or atenolol daily)
    – The drugs are the most efficacious in their class (atenolol, +/- HCTZ)
Answer 8: Other Options

E. Pheochromocytoma

• No symptom complex suggestive of pheochromocytoma
  – Headache, tachycardia and sweats

• Headaches, palpitations can confuse the issue in an acute hypertensive episode
  – Due to catecholamines or high blood pressure?
Case 9:

A 55-year-old male with a history of small cell lung cancer is admitted to the hospital with weakness and confusion for the past 48 hours until this morning when he was minimally arousable.

BP 126/70, weight 65kg

He is arousable, not oriented

Oral mucosa are moist

Lungs are clear, no edema
Case 9, cont’d:

<table>
<thead>
<tr>
<th>Serum</th>
<th>Urine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium 118 mmol/L</td>
<td>Osmolality 450 mOsm/L</td>
</tr>
<tr>
<td>Potassium 4.0 mmol/L</td>
<td>Sodium 50 mmol/L</td>
</tr>
<tr>
<td>Cl 84 mmol/L</td>
<td></td>
</tr>
<tr>
<td>CO2 22 mmol/L</td>
<td></td>
</tr>
<tr>
<td>BUN 9 mg/L</td>
<td></td>
</tr>
<tr>
<td>Creatinine 0.9 mg/dL</td>
<td></td>
</tr>
<tr>
<td>Glucose 90 mg/dL</td>
<td></td>
</tr>
<tr>
<td>Uric acid 2.5 mg/dL</td>
<td></td>
</tr>
</tbody>
</table>
Question 9: All of the following will help this patient’s hyponatremia except:

A. Effective treatment of the malignancy if available
B. Free water restriction
C. Vasopressin antagonists
D. Isotonic saline
E. Furosemide
Answer 9: D. Isotonic saline

- Syndrome of Inappropriate ADH Secretion (SIADH)
  - Known small cell lung cancer
  - Hyponatremia
  - High urinary sodium and osmolality
  - Low serum uric acid level
Urine Parameters and Hyponatremia

Intravascular
Vol. Depletion  SIADH  Polydipsia

UNa

UOsm

↑  ↓  ↓  ↓  ↓
Renal Handling of Water

Osmolality
50

Osmolality
1200

Water load

Na
K
2Cl

AVP

H2O

Osmolality
1200

Urine Osmolality

AQ2
Renal Handling of a Water Load

• Assume 600mOsmo dietary intake
  – Minimal urinary osmolality of 50 mOsmo/L
  – Maximum urinary osmolality of 1200 mOsmo/L

• What is the minimum and maximum amount of water you can drink in a day and still handle the water load solely through urination?

  0.5L – 12L
Renal Handling of a Water Load

• Assume 200mOsmo dietary intake
  – Minimal urinary osmolality of 100 mOsmo/L
  – Maximum urinary osmolality of 800 mOsmo/L
  (elderly female tea and toaster)

• What is the minimum and maximum amount of water you can drink in a day and still handle the water load solely through urination?

0.25L – 2L (8 cups of tea per day)
Renal Handling of a Water Load

- Any water intake beyond the maximum amount for a given minimum urinary osmolality must be retained as free water
  - Leads directly to hyponatremia
Renal Handling of a Water Load: SIADH

- Assume 600mOsmo dietary intake
  - Urinary osmolality fixed at 450mOsmo/L

- What is the maximum amount of water you can drink in a day and not retain free water leading to hyponatremia?

  $\frac{600}{450} = 1.3L$
Renal Handling of a Water Load

SIADH

• Assume 600mOsmo dietary intake
  – Urinary osmolality fixed at 450mOsmo/L

• What is the impact of infusing 1L normal saline (osmolality = 308 mOsmo/L)?

- 0.67L urine at 450mOsmo/L
- 0.33L retained free water

Sodium goes down!
Treatments for SIADH

- Osmolality 1200
- Osmolar load
- Water load
- Na
- K
- 2Cl
- H2O
- AQ2
- Osmolality 50
- V2 antagonists:
  - Demeclocycline
  - Vaptans
- Urine Osmolality
Question 10

A 22 yo female presents for further evaluation of fatigue. She is noted to have normal blood pressure, and examination is otherwise normal.

<table>
<thead>
<tr>
<th>Plasma</th>
<th>Urine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na+ 140 meq/L</td>
<td>Na+ 80 mEq/d</td>
</tr>
<tr>
<td>K+ 2.5 meq/L</td>
<td>K+ 170 mEq/d</td>
</tr>
<tr>
<td>Cl- 86 meq/L</td>
<td>Cl- 40 mEq/d</td>
</tr>
<tr>
<td>CO2 39 meq/L</td>
<td>Ca^{+2} 76 mg/d</td>
</tr>
<tr>
<td>Mag 1.7 MeQ/L</td>
<td></td>
</tr>
<tr>
<td>Aldosterone 25 ng/ml</td>
<td></td>
</tr>
</tbody>
</table>
After replenishment of her hypokalemia and hypomagnesemia with IV solutions, her fatigue resolves.

In further conversation with her, she states that she has had frequent muscle cramps and fatigue, which had limited her ability to play sports as a child.
Question 10: Which of the following is her *most likely* diagnosis?

A. Bartter’s syndrome
B. Gitelman’s
C. Surruptitious vomiting
D. Diuretic abuse
E. Liddle’s syndrome
Metabolic Alkalosis

- Saline sensitive vs. saline resistant
- Determined by urinary chloride, not sodium
  - Alkalosis causes bicarbonaturia
  - Accompanied by sodium
  - Chloride retained in place of bicarbonate, unless forced into urine by impaired exchangers
Metabolic Alkalosis

- **Saline sensitive**: Low UCl-
- **Any non-renal cause of alkalosis**:  
  - Volume depletion, emesis, etc
- **Saline resistant**: High UCl-
- **Renal source**:  
  - Normal/low BP: Diuretics, diuretic mimickers  
    (loop – Bartter’s, thiazide – Gitelman’s)  
  - High BP: Hyperaldo states – primary / secondary
Answer 10: Incorrect Options

• C. Surreptitious vomiting:
  – Low/normal BP, low urinary Cl⁻, high Aldo

• E. Liddle’s syndrome:
  – Upregulated sodium reabsorption
  – High BP, low Aldo

• Other: Renal artery stenosis:
  – High BP, high Aldo – rarely causes symptomatic hypokalemia
Differentiating Diuretic Abuse from Bartter’s/Gitelman’s

- Both have high urine chloride
- Both have upregulated renin and aldosterone
- Both can induce hypokalemia, hypomagnesemia and metabolic alkalosis

- History
  - Recurring issue – especially since childhood, thin genetic
  - Nursing or other medical field – diuretic abuse

- Diuretic screen will answer the question
Differentiating Bartter’s from Gitelman’s

• Bartter’s:
  – Mimics loop diuretics
  – Acts at NKC2 triporter in thick ascending limb
  – Causes increased calcium excretion in the urine

• Gitelman’s:
  – Mimics thiazide diuretics
  – Acts at NaCl transporter in distal convoluted tubule
  – Causes calcium reabsorption and low urine calcium

• 24 hour urine calcium collection differentiates
Answer 10: B. Gitelman’s Syndrome

- Developmental abnormalities common
- Low-normal BP
- High urine Cl⁻
- High aldosterone level
- Typical history is of repeated hypokalemia or undiagnosed fatigue
Nephrology Board Simulation

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