ABCs of the ABG, BMP and CBC
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No financial conflict of interest to disclose.

Objectives
• Identify and interpret commonly used laboratory parameters
• Analyze laboratory data for critical drug monitoring
• Assess response to therapy based on changes in laboratory parameters
• Identify critical values and discuss potential plans of action
Patient Case

<table>
<thead>
<tr>
<th></th>
<th>142</th>
<th>103</th>
<th>16</th>
<th>96</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na</td>
<td>4.5</td>
<td>26</td>
<td>0.87</td>
<td>15.1</td>
</tr>
<tr>
<td>Cl</td>
<td>10.0</td>
<td>291</td>
<td>45.7</td>
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</tbody>
</table>

Normal Values

<table>
<thead>
<tr>
<th></th>
<th>Na</th>
<th>Cl</th>
<th>CO2</th>
<th>BUN</th>
<th>Glucose</th>
<th>HGB</th>
<th>WBC</th>
<th>PLT</th>
<th>HCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Sodium (Na)</td>
<td>135-145 mmol/L</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>3.5-5 mmol/L</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloride (Cl)</td>
<td>99-109 mmol/L</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO2 (Bicarbonate)</td>
<td>21-28 mmol/L</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BUN</td>
<td>8-25 mg/dL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Creatinine</td>
<td>0.7-1.3 mg/dL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glucose</td>
<td>65-99 mg/dL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</table>

Effects on CHEM-7

<table>
<thead>
<tr>
<th></th>
<th>142</th>
<th>103</th>
<th>40</th>
<th>96</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na</td>
<td>5.0</td>
<td>26</td>
<td>1.3</td>
<td>1.3</td>
</tr>
</tbody>
</table>

- Expected responses of ACE-I:
  - Hyperkalemia
  - Change in renal function
- What should you do?
- When should I worry?

<table>
<thead>
<tr>
<th></th>
<th>Sodium (Na)</th>
<th>Potassium (K)</th>
<th>Chloride (Cl)</th>
<th>CO2 (Bicarbonate)</th>
<th>BUN</th>
<th>Creatinine</th>
<th>Glucose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory</td>
<td>135-145 mmol/L</td>
<td>3.5-5 mmol/L</td>
<td>99-109 mmol/L</td>
<td>21-28 mmol/L</td>
<td>8-25 mg/dL</td>
<td>0.7-1.3 mg/dL</td>
<td>65-99 mg/dL</td>
</tr>
</tbody>
</table>
Patient Worsens

<table>
<thead>
<tr>
<th>Serum Creatinine (mg/dL)</th>
<th>Creatinine Clearance (mL/min)</th>
<th>GFR (mL/min/1.73m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>142</td>
<td>103</td>
<td>96</td>
</tr>
<tr>
<td>6.0</td>
<td>12</td>
<td>3.96</td>
</tr>
</tbody>
</table>

- Laboratory abnormalities?

The relationship between serum creatinine concentration, creatinine clearance, and glomerular filtration rate (GFR), shown with a 95% confidence interval (blue band).

Causes of Hyperkalemia

- Renal Failure
- Drugs
- Metabolic acidosis
- Hypoaldosteronism
- Pseudohyperkalemia
Hyperkalemia

- Signs and Symptoms
  - Muscle weakness
  - Fatigue
  - Nausea

- Treatment
  - Removal
  - Stabilization
  - Shifting

Patient Case 2

- JB is a 45 year–old male who complains of headache and fatigue for the past 3 months.
- Vital Signs: HR 97, BP 110/60, RR 15
- PE: pallor of the skin
- Laboratory: RBC 3.8 x 106 cells/mm³, MCV 80 cubic microns, RDW 18

Patient Case 2

- What labs should we order?
- What type of anemia is present?
- Interpretation of laboratory parameters for anemia.
- Pt follow up
Patient Case 3

- TH is a 45 year old male that comes to you complaining of anxiety, weakness, tremor, palpitations and weight loss.
- PE: sweaty and tremor noted
- Vitals: HR 105, RR 20, BP 140/82
- Laboratory: TSH <0.05 mU/L, T4 18.2mcg/dL, T3 300 ng/dL

What is the diagnosis?
- TSH normal: 0.5-4.7 mIU/mL
- Free T4: 0.8-2.7 ng/dL
- Total T3: 60-181 ng/dL

Treatment options?

Monitoring

Hypothyroidism

- Symptoms: dry skin, cold intolerance, weight gain, constipation, myalgia

- Treatment
  - T3
  - L-thyroxine
  - Natural thyroid

- Monitoring: 6 weeks until euthyroid
Thyroid Feedback Loop

Hypothalamus
Thyrotropin Releasing Hormone (TRH)
Pituitary Gland
Thyroid Stimulating Hormone (TSH)
Thyroid Gland
Thyroid Hormones

Patient Case 4

- HPI: 57 year old male found down in the street. He is confused upon admission and is coughing up blood.
- PMH: Alcohol abuse and hypertension
- Physical Exam: splenomegaly, scleral icterus, and ascites

Case Continued

<table>
<thead>
<tr>
<th></th>
<th>Calcium: 7.0 mg/dL</th>
<th>Alk Phos: 120 U/L (35-115)</th>
<th>T. Bili: 10.2 mg/dL (0.2-1.1)</th>
<th>PT: 20.3 sec</th>
<th>PT Control: 13.4 sec</th>
<th>Albumin: 2.2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>125</td>
<td>2.9</td>
<td>90</td>
<td>10</td>
<td>96</td>
<td>96</td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>0.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- AST 380 U/L (10-45)
- ALT 165 U/L (10-65)
- GGT 60 U/L (0-45)
- INR 1.6
- NH₃ 65
Case Continued

• What labs assess liver function? Damage? Obstruction?
• Which lab values are associated with the following clinical findings:
  – Scleral icterus
  – Ascites
  – Confusion
• How does liver disease elevate the INR?

Case Continues

• Alcoholic Hepatitis:
  Discirnant Function=4.6*(Pt PT - Control PT) + Tbil
  – Pentoxifylline
  – Prednisolone

• Hypocalcemia:
  Corrected calcium= 0.8*(4-Pt Albumin) + Serum Ca

Patient Case 5

• RW is a 23 year old female who presents to her health care provider’s office with a cc of fever, chills, dysuria, back pain, and urinary urgency
• Laboratory:
<table>
<thead>
<tr>
<th>Lab</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nit</td>
<td>Positive</td>
</tr>
<tr>
<td>Bacteria</td>
<td>Positive</td>
</tr>
<tr>
<td>Protein</td>
<td>Trace</td>
</tr>
<tr>
<td>RBC</td>
<td>&lt;1/hpf</td>
</tr>
<tr>
<td>WBC</td>
<td>&gt;182/hpf</td>
</tr>
<tr>
<td>Glucose</td>
<td>&gt;1000</td>
</tr>
<tr>
<td>Urine Leuk Esterase</td>
<td>Large</td>
</tr>
</tbody>
</table>

Differential: Segs 76%, Bands 13%, Lymphs 10%, Eos 1%
**Urine Analysis Interpretation**

- Leukocyte Esterase: enzyme produced by WBC
- Nitrites: GNR convert nitrates to nitrites in the urine
- WBC: Pyuria
- RBC vs Blood

**WBCs**

- Seg
- Band
- Eosinophil
- WBC
- Lymphocyte
- Basophil
- Monocyte

**Case 5 Continued**

- ABG
  - pH 7.19
  - pCO₂ 22
  - pO₂ 80
  - HCO₃ 12
  - pCO₂ 22
  - pO₂ 80
  - HCO₃ 12
  - pCO₂ 22
  - pO₂ 80
  - HCO₃ 12
Acidic vs Basic

<table>
<thead>
<tr>
<th>Primary Disorder</th>
<th>Normal Range</th>
<th>Primary Disorder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acidosis</td>
<td>7.35-7.45</td>
<td>Alkalosis</td>
</tr>
<tr>
<td>Respiratory Alkalosis</td>
<td>35-45</td>
<td>Respiratory Acidosis</td>
</tr>
<tr>
<td>Metabolic Acidosis</td>
<td>22-26</td>
<td>Metabolic alkalosis</td>
</tr>
</tbody>
</table>


DKA vs HHS

<table>
<thead>
<tr>
<th></th>
<th>Mild DKA</th>
<th>Mod DKA</th>
<th>Severe DKA</th>
<th>HHS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose</td>
<td>&gt;250</td>
<td>&gt;250</td>
<td>&gt;250</td>
<td>&gt;600</td>
</tr>
<tr>
<td>pH</td>
<td>7.25–7.30</td>
<td>7.00–7.24</td>
<td>&lt;7.00</td>
<td>&gt;7.30</td>
</tr>
<tr>
<td>Serum bicarbonate</td>
<td>15–18</td>
<td>10 to &lt;15</td>
<td>&lt;10</td>
<td>&gt;15</td>
</tr>
<tr>
<td>Urine and serum ketones</td>
<td>positive</td>
<td>positive</td>
<td>positive</td>
<td>Small</td>
</tr>
<tr>
<td>Anion gap</td>
<td>&gt;10</td>
<td>&gt;12</td>
<td>&gt;12</td>
<td>variable</td>
</tr>
<tr>
<td>Serum osmolality</td>
<td>Variable</td>
<td>Variable</td>
<td>Variable</td>
<td>&gt;320</td>
</tr>
<tr>
<td>Mental status</td>
<td>Alert</td>
<td>Alert/drowsy</td>
<td>Stupor/coma</td>
<td>Stupor/coma</td>
</tr>
</tbody>
</table>

Diabetes Care, Volume 27, Supplement 1, January 2004.

Calculations

- Anion Gap = Positives – Negatives

- Serum Osmolality = 2 (Na) + BUN/2.8 + Glucose/18

- Corrected Sodium: (Serum Glucose – 100) * 0.016 + Measured sodium

Patient Case 6

• KS is an 82 year old male presenting to the ER with SOB, cough, and fever
• Vital Signs: Temp: 102° F, RR 24, HR 98, BP 100/60
• Physical Exam: Wheezing and rhonchi in lower lung fields
• Laboratory: WBC 18,000 with bands of 22%, procalcitonin 0.3ug/L

Role of Procalcitonin

• Prohormone for calcitonin
• Secreted by thyroid gland
• Inflammatory cascade
• Bacterial infection

<table>
<thead>
<tr>
<th>Level</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;0.1 ug/L</td>
<td>antibiotics strongly discouraged</td>
</tr>
<tr>
<td>&lt;0.25 ug/L</td>
<td>antibiotics discouraged</td>
</tr>
<tr>
<td>&gt;0.25 ug/L</td>
<td>antibiotics encouraged</td>
</tr>
<tr>
<td>&gt;0.5 ug/L</td>
<td>antibiotics strongly encouraged</td>
</tr>
</tbody>
</table>


Patient Case

• CD is a 64 year old female presenting to the hospital with cellulitis and abscess
• Medications: vancomycin, Zosyn, and enoxaparin
  Day 1        Day 3
  14.3  13.2  10.6  12.6
  39.8  260  20  220
  39.8  37.8
## 4Ts

<table>
<thead>
<tr>
<th>Category</th>
<th>2 points</th>
<th>1 point</th>
<th>0 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thrombocytopenia</td>
<td>Platelet fall &gt;50% and platelet nadir &gt;20,000</td>
<td>Platelet fall 30-50% or nadir 10,000-19,000</td>
<td>Platelet count fall &lt;30% or nadir &lt;10,000</td>
</tr>
<tr>
<td>Timing of platelet count fall</td>
<td>Onset between 5-10 days</td>
<td>Onset consistent but not clear</td>
<td>Platelet count fall &lt;4 days without previous exposure</td>
</tr>
<tr>
<td>Thrombosis or other sequelae</td>
<td>New confirmed thrombosis or acute necrosis at injection site</td>
<td>Progressive or recurrent thrombosis or non-necrotizing skin lesions or suspected thrombosis</td>
<td>None</td>
</tr>
<tr>
<td>Other causes</td>
<td>None apparent</td>
<td>Possible</td>
<td>Definite</td>
</tr>
</tbody>
</table>


## Therapy Options

- **Argatroban**  
  - Monitoring: aPTT
- **Lepirudin**  
  - Monitoring: aPTT
- **Bivalirudin**  
  - Monitoring: aPTT
- **Fondaparinux:**  
  - Monitoring: none

## Self Assessment 1

If a systemic bacterial infection is suspected, which of the following labs would help to verify this suspicion?

**Orange:** Procalcitonin  
**Yellow:** Lymphocytes  
**Pink:** ABG  
**Green:** SCr
Self Assessment 2

Which of the following would you expect to happen to potassium with administration of insulin?

Orange: Be excreted by the kidney
Yellow: Go intracellular
Pink: Go extracellular
Green: No change

Self Assessment 3

MCV will tell you whether microcytic or macrocytic type of anemia?

Orange: True
Yellow: False

Self Assessment 4

Which test is the most sensitive to detect a B12 deficiency anemia?

Orange: B12 level
Yellow: Ferritin
Pink: Methylmalonic acid
Green: Red blood cell folate
Self Assessment 5
CM is a 72 year old male who is starting Lisinopril for CAD. His SCr last week was 1.0 and his SCr today is 1.15. What would you recommend for CM?
Orange: stop lisinopril because his SCr increased too much
Yellow: continue lisinopril because this is an expected and appropriate change in SCr.
Pink: stop lisinopril because ACE-I are not good for CAD

Self Assessment 6
RJ began taking levothyroxine 2 weeks ago for hypothyroidism. Today’s labs show: TSH 10.3 mIU/L. What would you recommend?
Orange: check another TSH next week
Yellow: check another TSH 4 weeks
Pink: increase levothyroxine dose
Green: decrease levothyroxine dose