I Found the Lab Value- Now What?
Demystifying Lab Values for Patient Management

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Objectives

Upon Completion of this course, the learner will:
1. Recognize the importance of reviewing lab values prior to initiating an examination/intervention.
2. Describe the clinical considerations related to abnormal lab values.
3. Classify lab values that are pertinent to physical therapy professionals and their implications on various systems.
4. Utilize the Lab Resources Guide to identify relative and absolute parameters for therapeutic participation.

Overview
Consensus Statement:
Academy of Acute Care Physical Therapy

It is the professional responsibility of the physical therapist to:

• Interpret available laboratory values

• To suggest laboratory testing when indicated

• To use lab values to guide the determination of safe and effective interventions for the patient/client.

Lab Values Resource Update 2012, 2017

Academy of Acute Care Resources

• AACPT Home  http://www.acutept.org/
• Journal of Acute Care Physical Therapy
• PTA Advanced Proficiency
• Total Joint Replacement SIG
• ED Focus Group
• ICU Focus Group
• Amputee Rehabilitation Focus Group
• Acute Care practice forum: Acutept@yahoo groups.com

PT Specific Resources (history)

1995 Garritan et all, Laboratory values in the intensive care unit. Acute Care Perspectives
1996 Polich S, Faynor S., Interpreting Lab Test Values. PT Magazine
2004 Irion G. Lab values update. Acute Care Perspectives
2006 Hergenroeder A, Implementation of a competency-based assessment for interpretation of laboratory values. Acute Care Perspectives
2009 Billek-Sawhney B. Wells C. Oncological implications for exercise and rehabilitation. Acute Care Perspectives
PT Specific Resources (history)

2008, 2009, 2012, 2017 (pending) - APTA Academy of Acute Care Physical Therapy (formerly Acute Care Section)


2013 Pawlik A, Kress J Issues affecting the delivery of physical therapy services for individuals with critical illness. Physical therapy


2015 Peterson M. The Impact of Low Hemoglobin on the Percentage of Adverse Events During Physical Therapy in the Acute Care Setting: A Retrospective Study. JACPT.


History of the Lab Resources Document

2009 • Creation of Only APTA Lab Values Resource Document

2012 • Revision of Lab Values Resource Document

2015 • Identification of need for revision of document

History of the Lab Resources Document

Fall 2015 • AACPT Board approval of Lab Values Resource Guide Update

Dec 2015 Jan 2016 • Identification of Subcommittee members and co-chairs for Taskforce December 2015/January 2016

Jan/Feb 2016 • Review of previous document and identification of areas of edits; selection of common platform for committee work; review references
### History of the Lab Resources Document

<table>
<thead>
<tr>
<th>Month</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>March-April 2016</td>
<td>• Prework including reference values for different institutions, top lab values needed for document</td>
</tr>
<tr>
<td>May 2016</td>
<td>• 1st committee meeting and determination of framework for updated document</td>
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<tr>
<td>Summer 2016</td>
<td>• Monthly committee meetings and quick turnaround on assignments</td>
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</table>

<table>
<thead>
<tr>
<th>Month</th>
<th>Activities</th>
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<tbody>
<tr>
<td>August-Sept 2016</td>
<td>• Completion of main document</td>
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<tr>
<td>October 2016</td>
<td>• Start of Point of Care document</td>
</tr>
<tr>
<td>Nov 2016</td>
<td>• Completion of Point of Care document</td>
</tr>
<tr>
<td></td>
<td>• Submission of document for BOD approval</td>
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</table>
Laboratory Value Interpretation Resource

- Recognize basic laboratory tests and normative values
- Recognize absolute and generalized parameters to exercise and therapeutic interventions
- Should complement not replace a thorough evaluation and clinical judgment
- Follow institutional guides
- Should not be used as an excuse not to treat!!!
Why a symptoms based approach?

Mobility of patients along a progressive continuum
- Readiness
- Specific pathology
- Activity tolerance
- Prevent complications

Plethora of studies supporting early mobilization as safe and feasible

Readmissions – Articles:

Why a symptoms based approach?

Lack of early mobility independent predictor for readmission or death
- Baroreceptor dysfunction
  - Affects vestibular response
- Increased cardiovascular workload
  - Increased resting heart rate, decreased stroke volume

Immobility leads to long-term impairments
Impacts quality of life

What is a Symptoms Based Approach?

Clinical decision making
- Monitor vitals
  - HR, BP, RR, SpO2, EKG
  - HR < 60 or > 120
  - SBP < 90 or > 180
  - SpO2 < 90%
  - Dysrhythmia
- Patient symptomology
  - New onset or worsens
  - Trend

Collaboration with the health care team
The human movement system comprises the anatomic structures and physiologic functions that interact to move the body or its component parts.
Physical Therapist Practice and the Human Movement System

Human movement is a complex behavior within a specific context.

Physical therapists provide a unique perspective on purposeful, precise, and efficient movement across the lifespan based upon the synthesis of their distinctive knowledge of the movement system and expertise in mobility and locomotion.


Physical Therapist Practice and the Human Movement System

Physical therapists examine and evaluate the movement system (including diagnosis and prognosis) to provide a customized and integrated plan of care to achieve the individual's goal-directed outcomes.


Physical Therapist Practice and the Human Movement System

Physical therapists maximize an individual's ability to engage with and respond to his or her environment using movement-related interventions to optimize functional capacity and performance.

Reference Range

- AKA - normal range
- Depicts homeostasis
  - Varies with age, sex, weight, fluid status, physiologic changes
  - Individuals with different tolerances
- Not meant to be memorized and applied as a standard to every case
- Trends

Average person has 5.5 L blood

**PLASMA** - 52% of Total Blood Volume
91% Water
2% Blood Proteins (fibrinogen, albumin, globulin)
2% Nutrients (amino acids, sugars, lipids)
Hormones (thyroxine, insulin, etc.)
Electrolytes (sodium, potassium, calcium, etc.)

**CELLULAR COMPONENTS** - 47% of Total Blood Volume

- **Reticule Cell**
- White Blood Cells (7000-9000) per mm³ of blood
- Platelets (250,000) per mm³ of blood
- Red Blood Cells (RBCs)
  - About 5,000,000 per mm³ of blood
Metric equivalents

Key to abbreviations:
L = liter
dL = deciliter = 0.1 liter
mg = milligram
mmol = millimole
mEq = milliequivalents
μL = one millionth of a liter = 1 mm³

1 L = 1000 mL = 0.001 m³ = .000001 m

Critical Values

First defined in 1972 by GD Lundberg
"Pathophysiologic states at such variance with normal as to be life-threatening unless something is done promptly and for which some corrective action can be taken"

When to panic over abnormal values

Lundberg GD. Critical (panic) value notification: an established laboratory practice policy (parameter) [editorial]. JAMA. 1990;263:709

Complete Blood Count (CBC)
Complete Blood Count

Routine Test of Blood (RBC, WBC, PT)
Screens for:
• Anemia
• Infection
• Coagulation disorders

Different levels of "complete" blood detail
Valuable to therapists to determine tolerance to mobilization and exercise

Cellular Components of Blood

Complete Blood Count
• White Blood Cells
  • differential
• Red Blood Cells
  • Hemoglobin
  • Hematocrit
  • Platelets

Complete Blood Count

<table>
<thead>
<tr>
<th>WBC (10⁹/L)</th>
<th>Hematocrit (%)</th>
<th>Hemoglobin (g/dL)</th>
<th>PLT (ku/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult Male</td>
<td>5.0-10</td>
<td>42-52</td>
<td>14.0-17.4</td>
</tr>
<tr>
<td>Adult Female</td>
<td>5.0-10</td>
<td>37-47</td>
<td>12-16</td>
</tr>
</tbody>
</table>
### Leukocytes – total WBC

| Neutrophils | • Rapid response to infection and tissue injury  
| Eosinophils  | • Increase during allergic and parasitic conditions  
| Basophils    | • Primarily seen in allergic reactions  
| Monocytes   | • Second defense against infection and foreign substances  
| Lymphocytes | • Increase in chronic and viral infections  
|             | • T lymphocytes (T cells) - cell-mediated immunity  
|             | • B lymphocytes - humoral immunity (antibody production) |

### White Blood Count

- **WBC (leukocytes)**
  - Cells of the immune system
  - Protect against infectious disease and foreign invaders
  - Leukocytosis (trending up)
    - > 11.0 $10^9$/L
  - Leukocytopenia (trending down)
    - < 4.0 $10^9$/L
  - Neutropenia (trending down)
    - < 1.5 $10^9$/L

### Leukocytopenia

- Decreased Levels (WBC < 4.0 $10^9$/L)
  - Malignancy, hematologic, and 1st bone marrow disorders
  - Metastatic invasion of bone marrow
  - Drug-induced and Immunosuppressive agents

Implications
- Nosocomial infections
  - Greek word *nosokomeion* meaning hospital
    - *nosos* (disease)
    - *komeo* (to take care of)
  - Questionable tolerance to therapy
# Neutropenia

- WBC 1.0-1.5 k/μL (mild neutropenia)
  - Immunosuppressed status
- WBC 0.50-1.0 k/μL (moderate neutropenia)
- WBC < 0.50 k/μL (severe neutropenia)

** Initiate neutropenic precautions based upon facility infection control guidelines

# Leukemia

- Malignancy (cancer)
  - Rapid multiplication of undifferentiated infant leukocytes

**Characteristics**

- Suppression of normal RBC production (anemia)
- Suppression of normal platelet production (thrombocytopenia)
- Inhibition of normal WBC (neutrophils) production leads to an immunosuppressed state.

# Altered WBC Levels (Implications)

- Symptoms-based approach when determining appropriateness for activity
  - Especially in the presence of fever.
- Consider timing of therapy session
  - Early-morning low level and late-afternoon high peak
- Neutropenic precautions
  - Dependent upon facility guidelines
Clinical Bottom Line (WBC)

Patients with altered WBC will most likely present with decreased energy (tolerance)

Patients with low WBC are at risk for further infections

Modalities may be contraindicated if patient has an active infection or acute inflammation

Intense exercise may be contraindicated during active infection

Complete Blood Count

- Hematocrit - Total % RBC
  - Proportion of cells to fluid
  - Assists in diagnosing abnormal states of hydration

- Hemoglobin – protein in RBC that carries oxygen

Hematocrit (Clinical Implications)

**REFERENCE VALUES:** Men: 42-52%  Women: 37-47%

Low critical value
  • < 15-20% - cardiac failure or death

High critical value
  • > 60% - spontaneous blood clotting

Consultation with the interprofessional team
Monitor signs and symptoms when determining appropriateness for activity
Hemoglobin (Clinical Implications)

**REFERENCE VALUES:** Men: 14-17.4 g/dL Women: 12-16 g/dL

- **Low critical value**
  - < 5.0-7.0 g/dL

- **High critical value**
  - > 20 g/dL - spontaneous blood clotting

Consultation with the interprofessional team
Monitor signs and symptoms when determining appropriateness for activity

Anemia (Reduction of RBC)

**Etiology**
- Iron deficiency
- Chronic Inflammatory Disease
- Cancer
- Hemorrhage
  - Internal
  - External

**Symptoms**
- Dyspnea
- Confusion
- Fatigue
- Weakness
- Hypotension
- Tachycardia

Anemia (Clinical Implications)

- Requires close monitoring of vitals (BP, HR)
- \( \text{SpO}_2 \) to predict tissue perfusion
  - Clinical significant (desaturation)
    - \( \text{SpO}_2 < 88\% \) during exercise
    - \( \text{SpO}_2 \) decrease 4% or more from baseline
  - ?? accuracy when Hgb < 9 g/dL
- If < 8 g/dL
  - Symptoms-based approach when determining appropriateness for activity
  - Collaborate with health care team
Life Saving Blood Transfusion?

Blood Transfusions

• ↑ utilization
• ↑ length of stay
• ↑ morbidity (infections, thrombus)
• ↑ mortality

Current Recommendations: Primary strategy is to avoid transfusion if at all possible

Shander A. Blood Transfusion as a Quality Indicator in Cardiac Surgery JAMA. 2010;304(14):1610-1611.
Hajjar L. TRACS: Differing blood transfusion strategies yield similar complications, death rates in cardiac surgery patients. JAMA. 2010;303:1560-1567

RBC Transfusions (CPG 2016)

< 8 g/dL
• Post-surgical, cardiac or orthopedic patients and those with underlying cardiovascular disease

< 7 g/dL
• Hospitalized patients who are hemodynamically stable

No transfusion threshold recommendation available for:
• Hematological disorders
• Oncological disorders
• Severe thrombocytopenia
• Chronic transfusion-dependent anemia


Mobilizing during RBC transfusions?

• Lack of evidence re: PT and transfusion
• Ohio e-survey (262 PT/PTA respondents)
  • 9.2% with institutional policy
  • 54.8% comfortable delivering care
• When did the respondents say no
  • Avg ~ minimum of 6.9 g/dL

Conclusion: need further research

**Polycythemia (Erythrocytosis)**

**Primary**
- Disease of the bone marrow – Unknown etiology

**Secondary (compensatory)**
- Physiological manifestation
- Due to decreased O₂ supply
  - Altitude
  - Nicotine
  - Chronic pulmonary/cardiac deficits

Presentation: Fever, headache, dizziness, blurred vision, weakness, fatigue, easy bruising or bleeding, decreased mental acuity, sensory disturbances in hands and feet

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**Platelets (thrombocytes)**

**Reference Value 140-400 k/μL**

Responsible for initiation of clotting

Thrombocytosis (trending up)
- < 450 k/μL

Thrombocytopenia (trending down)
- < 150 k/μL

**Thrombocytes**

**Primary Function – Hemostasis**

Thrombocytosis
- Elevated platelets

Thrombocytopenia
- Decreased platelets
- Reduced by:
  - aspirin
  - medications
  - diet
  - liver disease
  - chemotherapy/radiation
### Thrombocytosis
(Platelets > 450 k/uL)

**Causes:**
- Iron deficiency
- Neoplasm
- Infection
- Inflammation
- Splenectomy

**Presentation:**
- weakness, headache, dizziness, chest pain, tingling in hands/feet

**Clinical Implications:**
- Impaired tolerance to activity, increased risk for clotting

### Thrombocytopenia
(Platelets < 150 k/uL)

**Causes:**
- Leukemia
- Bone marrow destruction from chemo-radiation treatments
- Medications
- Menorrhagia (excessive menstruation)

**Presentation:**
- Excessive bleeding (GI, nasal, respiratory, SDH)
- Melena
- Petechiae

**Clinical Implications:** Increased risk for bleeding, weakness, headache, dizziness, chest pain, tingling in hands/feet, skin tears, impaired wound healing

### Thrombocytopenia

**Low blood platelet count**

**Symptoms**
- Excessive bruising (purpura)
- Superficial bleeding into the skin that appears as a rash of pinpoint-sized reddish-purple spots (petechiae)
- Prolonged bleeding from cuts
- Bleeding from gums or nose
- Blood in urine or stools
- Unusually heavy menstrual flows
- Fatigue
Additional considerations

- Thrombocytopenia can result in heavy bleeding
  - CNS or GI tract
  - Check for coagulation factor deficiency
- Screen for fall risk
- Following guidelines (2013 APTA Acute Care Lab Resource)
  - > 50 k/uL
    - Resistive AROM permitted
    - Therapeutic exercise/activities (cycle with/ or w/o resistance)
  - 20-50 k/uL
    - Light exercise (no resistive)
  - < 20 k/uL. Symptoms based approach, high risk for bleeding

Guidelines for Exercise
(2012 APTA Acute Care Section Lab Value Guidelines)

<table>
<thead>
<tr>
<th>Hct</th>
<th>Hgb</th>
<th>WBC</th>
</tr>
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<tbody>
<tr>
<td>&lt; 25%</td>
<td>Light ROM and isometrics Avoid aerobic or progressive programs</td>
<td>&lt; 8.0 gm/dL Light ROM and isometrics Avoid aerobic or progressive programs</td>
</tr>
<tr>
<td>25-35%</td>
<td>Essential ADL's Assistance for safety light aerobics or weights</td>
<td>8.0-10 gm/dL Essential ADLs Assistance for safety Light aerobics or weights</td>
</tr>
<tr>
<td>&gt; 35%</td>
<td>Mobilize and self care as tolerated Resistance exercises</td>
<td>&gt; 10.0 gm/dL Ambulation and self care as tolerated, resistance ex</td>
</tr>
<tr>
<td>&lt; 25%</td>
<td>Light ROM and isometrics Avoid aerobic or progressive programs</td>
<td>&lt; 5.0 10^9/L (w/fever) No exercise permitted</td>
</tr>
<tr>
<td>&lt; 25%</td>
<td>Symptoms based approach</td>
<td>&gt; 5.0 10^9/L Light exercise progress to resistive exercise permitted</td>
</tr>
<tr>
<td>&gt; 60%</td>
<td>Spontaneous blood clotting</td>
<td>&gt; 11.0 10^9/L Leukocytosis</td>
</tr>
<tr>
<td>&lt; 8 g/dL</td>
<td>Symptoms-based approach</td>
<td>&lt; 4.0 10^9/L Leukopenia</td>
</tr>
<tr>
<td>&gt; 20 g/dL</td>
<td>Can lead to clogging of capillaries as a result of hemoconcentration</td>
<td>Especially in the presence of fever</td>
</tr>
</tbody>
</table>

Guidelines for Exercise
(2017 APTA Academy of Acute Care Lab Value Guidelines)

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<tr>
<th>Hct</th>
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<tr>
<td>&lt; 15-20% (critically low value) Cardiac failure or death</td>
<td>&lt; 5-7 g/dL (critically low value) Can lead to heart failure or death</td>
<td></td>
</tr>
<tr>
<td>&lt; 25%</td>
<td>Symptoms based approach</td>
<td>&lt; 8 g/dL Symptoms-based approach</td>
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<tr>
<td>&gt; 60% (critically high value) Spontaneous blood clotting</td>
<td>&gt; 20 g/dL (critically high value)</td>
<td></td>
</tr>
<tr>
<td>&lt; 11.0 10^9/L Leukocytosis</td>
<td>&lt; 4.0 10^9/L Leukopenia</td>
<td></td>
</tr>
<tr>
<td>&lt; 1.5 10^9/L Neutropenia</td>
<td>Especially in the presence of fever</td>
<td></td>
</tr>
<tr>
<td>&lt; 1.5 10^9/L Neutropenia</td>
<td>Symptoms based approach</td>
<td></td>
</tr>
<tr>
<td>Facility based neutropenic procedures</td>
<td>Facility based neutropenic procedures</td>
<td></td>
</tr>
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</table>
Blood Viscosity

Not the same viscosity at all times
• As blood slows down increased viscosity
  • Diastole
  • High iron
  • Dependent position
  • Inactivity

Factors affecting bleeding viscosity
• Hematocrit
• RBC (red blood cell) deformability (example Sickle Cell Disease)
• Plasma viscosity
• RBC sedimentation/aggregation

Bleeding and Clotting Disorders

The Precarious Balance

The anticoagulants vs. the procoagulants

Physics of Blood Viscosity
Hemostasis

Relevant factors
- Platelets
- Enzymes
  - Initiate, promote, or inhibit
  - Binding of coagulation factors
- Calcium

Basics of Clotting

Virchow's Triad
- Changes in vessel wall
- Changes in blood composition
- Changes in the blood flow

Mechanisms to keep the coagulation cascade in homeostasis
- Blood flow → Dilutes and washes away any clotting factors that get activated
- Normal levels of Protein C, Protein S, Antithrombin, Tissue Factor Pathway Inhibitor (TFPI) → Inhibit clots
- Fibrinolytic system → Breaks down clots after they've formed
Hemostasis pathways

- Biochemical pathways involving several enzymes that react in a sequence resulting in a fibrin network (clot)
- Three pathways
  - Intrinsic
    - activated in bloodstream
  - Extrinsic
    - activated outside bloodstream by tissues
  - Common
    - activated by the intrinsic and extrinsic pathways
Excessive Bleeding Disorders

Hemophilia A = Factor VIII deficiency
- Abnormal PTT and factor VIII assay
Hemophilia B = Factor IX deficiency
- Abnormal PTT and factor IX assay
Hemophilia C = Factor XI deficiency
- Abnormal PTT and factor XI assay
Von Willebrand disease
Bone marrow suppression

Clotting Disorders

<table>
<thead>
<tr>
<th>Thrombophilia</th>
<th>Acquired</th>
<th>Inherited</th>
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</thead>
<tbody>
<tr>
<td>Antithrombin deficiency</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Factor V Leiden</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Prothrombin gene mutation</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Protein C deficiency</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Protein S deficiency</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Elevated levels of factor VIII*</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Elevated levels of factor IX, XI*</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Antiphospholipid antibody syndrome (APS)</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

Hemostasis

- DNA testing to determine inherited defect
- Antiphospholipid antibodies
- Antithrombin deficiency and protein C deficiency
- Protein S deficiency
- Fibrinogen Assay
  - Quantitates fibrinogen
  - Normal = 200 - 400 mg/dL
- Factor Assays
  - Quantitates all coagulation factors
  - Normal = 50 - 150%
Clotting Disorders - Disseminated Intravascular Coagulation

Excessive clotting
Consumes clotting factors and platelets
↑PT, ↑PTT, ↓fibrinogen, ↓factor assays, ↓platelets, ↑D-dimer, ↑fibrin degradation product

Clotting Disorders – Deep Vein Thrombosis

Risk factors
Signs and symptoms
Complications
• Pulmonary embolism
• Post thrombotic syndrome
N-PT, N-PTT, N-fibrinogen, N-factor assays, N-platelets, ↑D-dimer, ↑fibrin degradation product

Well’s Criteria for DVT

<table>
<thead>
<tr>
<th>Clinical Feature</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active cancer (treatment ongoing, within 6 mo, or palliative)</td>
<td>1</td>
</tr>
<tr>
<td>Paralysis, paresis, or recent plaster immobilization of LE</td>
<td>1</td>
</tr>
<tr>
<td>Bedridden 3 days or longer or major sx within 12 wks requiring general or regional anesthesia</td>
<td>1</td>
</tr>
<tr>
<td>Localized tenderness along the distribution of the deep venous system</td>
<td>1</td>
</tr>
<tr>
<td>Entire LE swollen</td>
<td>1</td>
</tr>
<tr>
<td>Calf swelling at least 3 cm larger than asymptomatic side</td>
<td>1</td>
</tr>
<tr>
<td>Pitting edema confined to the symptomatic leg</td>
<td>1</td>
</tr>
<tr>
<td>Collateral superficial veins (necareous)</td>
<td>1</td>
</tr>
<tr>
<td>Previously documented DVT</td>
<td>1</td>
</tr>
<tr>
<td>Alternative diagnosis at least as likely as DVT</td>
<td>2</td>
</tr>
</tbody>
</table>

**Well’s Criteria for DVT** (Wells, 2014; Hillegass, 2016)

Identify the likelihood of LE DVT when signs and symptoms are present

- Wells criteria modified to a 2-stage stratification (2014) in conjunction with D-Dimer did not compromise patient safety
  - DVT likely 2 points or more
  - DVT unlikely less than 2 points

---

**Well’s Criteria for PE**

<table>
<thead>
<tr>
<th>Clinical Feature</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinically suspected DVT</td>
<td>3.0</td>
</tr>
<tr>
<td>No alternative diagnosis better explains the illness</td>
<td>3.0</td>
</tr>
<tr>
<td>Tachycardia</td>
<td>1.5</td>
</tr>
<tr>
<td>Immobilization (&gt;1 d/ surgery in previous four weeks)</td>
<td>1.5</td>
</tr>
<tr>
<td>History of DVT or PE</td>
<td>1.5</td>
</tr>
<tr>
<td>Hemoptysis</td>
<td>1.0</td>
</tr>
<tr>
<td>Malignancy (with treatment within 6 months) or palliative</td>
<td>1.0</td>
</tr>
</tbody>
</table>

**Traditional interpretation**

- > 6.0 - High (probability 59%)
- 2.0 to 6.0 - Moderate (probability 29%)
- < 2.0 - Low (probability 15%)

**Alternative interpretation**

- > 4 - PE likely
  - Consider diagnostic imaging
- 4 or less - PE unlikely
  - Consider D-Dimer to rule out PE

---

**D-Dimer**

Degradation product of fibrin clots resulting from the action of three enzymes:

- Thrombin
  - Due to activation of the coagulation cascade that converts fibrinogen into fibrin clots
- Activated factor XIII
  - Cross-links fibrin clots
- Plasmin

**Imaging**

- Venous Duplex
- Venography
**Activated Partial Thromboplastin Time (Heparin)**

- Normal: 22 - 31 seconds
- Evaluates the intrinsic and common pathways
- Monitors patient on heparin
  - Therapeutic
  - 2 to 2.5 times normal range (60 - 109 secs)
  - Variability in reagents

**Prothrombin Time (PT) (Coumadin)**

Prothrombin is a protein produced by the liver for clotting of blood
- Converted to thrombin during the clotting process
- Reduced in patients with liver disease

Production depends on adequate vitamin K intake and absorption

Detects and diagnoses a bleeding disorder or excessive clotting disorder

Normal Range: 11-13 secs

PT > 25 secs - High risk for bleeding into tissue

**International Normalized Ratio (INR) (Coumadin)**

Calculated from a PT result to minimize variations between labs

Monitors how well anticoagulant medication warfarin (Coumadin®) is working to prevent blood clots

\[ \text{INR} = \frac{\text{Patient PT}}{\text{Normal PT}} \]

\[ \text{↑ INR} \sim \text{↑ risk of bleeding} \]

- Extrinsic coagulation pathway
### International Normalized Ratio (INR)

<table>
<thead>
<tr>
<th>International Normalized Ratio (INR)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal range</td>
<td>0.8-1.2</td>
</tr>
<tr>
<td>Therapeutic Range (VTE, PE, patients with atrial fibrillation)</td>
<td>2.0 to 3.0</td>
</tr>
<tr>
<td>Therapeutic range for patients at higher risk (prosthetic heart valves)</td>
<td>2.5-3.5</td>
</tr>
<tr>
<td>Therapeutic range for patients with lupus anticoagulant</td>
<td>3.0-3.5</td>
</tr>
<tr>
<td>Therapeutic range for stroke prophylaxis</td>
<td>2.0-2.5</td>
</tr>
<tr>
<td>Patient at higher risk for bleeding</td>
<td>&gt; 3.6</td>
</tr>
</tbody>
</table>


### INR

**Increase (Risk of bleeding)**
- Antibiotics
- Amiodarone (Cordarone®)
- Steroids (depending on dose)
- Cimetidine

**Decrease (Risk of clotting)**
- Barbiturates
- Carbamazepine (Tegretol®)
- Rifampin
- Bosentan (Tracleer®)
- Vitamin K
- Prednisone

### Anti-Factor Xa Heparin Assay

Measures plasma heparin (unfractionated heparin [UH] and low molecular weight heparin [LMWH]) levels and monitors anticoagulant therapy.

- **Therapeutic ranges of heparin:**
  - LMWH: 0.5 - 1.2 IU/mL
  - UH: 0.3 - 0.7 IU/mL
- **Prophylactic ranges of heparin:**
  - LMWH: 0.2 - 0.5 IU/mL
  - UH: 0.1 - 0.4 IU/mL
What is the PTs Role?

Excessive Bleeding Clinical Considerations

- Resistance exercise
- Activities with risk of falling
- Education
- Medications
- Fall risk management
- Sharp debridement

Management of Individuals with Venous Thromboembolism (Hillegass, 2016)

- Advocate for a culture of mobility and physical activity
- Screen for risk of VTE
  - Patient interview and physical examination
- Provide preventive measures for LE DVT
  - Education for signs and symptoms of LE DVT
  - Activity
  - Hydration
  - Mechanical compression
Management of Individuals with Venous Thromboembolism

(Hillegass, 2016)

- Recommend mechanical compression for patients with LE DVT or when signs and symptoms of post thrombotic syndrome
- Mobilize patients after IVC filter placement once hemodynamically stable
- Verify the patient is taking an anticoagulant
  - Mobilize patients who are at a therapeutic level of anticoagulation

Anticoagulation Medications

**Oral Medications**
- Aspirin
- Clopidogrel (Plavix)
- Fondaparinux (Arixtra)
- Warfarin (Coumadin)
- Dabigatran (Pradaxa)
- Rivaroxaban (Xarelto)
- Apixaban (Eliquis)
- Savaysa (Edoxaban)

**Intravenous**
- Heparin
- Bridging
- Short acting

**Subcutaneous**
- Heparin
- Low molecular weight heparin (LMWH) (Lovenox)

Algorithm for Mobilizing Patients with Known Lower-Extremity Deep Vein Thrombosis

Labs

**Blood Chemistry Testing**
- Fluid Balance
- Body Water
- Electrolyte Balance

---

**Fluid Balance - Hypervolemia**

**Causes**
- Excess IV fluids
- Hypertonic Fluid
- Inadequate Output
  - CHF
  - Cirrhosis
  - Renal failure/insuff
  - Low protein
  - Steroid use

**Presentation**
- Pitting edema
- SOB
- Anasarca
- Jugular distension
- HTN
- Tachycardia
- Crackles

---

**Fluid Balance - Hypovolemia**

**Causes**
- Limited oral intake
- CVA
- AMS
- Excess loss
  - Vomiting/diarrhea
  - DM
  - Burns
  - Excessive Sweating

**Presentation**
- Dry Mucus Membranes
- Poor skin turgor
- Hypotension (orthostatic)
- Tachycardia
- Tachypnea
- AMS
Sodium
Hypernatremia Na+ > 150 mEq/L

<table>
<thead>
<tr>
<th>Causes</th>
<th>Presents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypovolemia</td>
<td>Irritability</td>
</tr>
<tr>
<td>Increased Na intake</td>
<td>Agitation</td>
</tr>
<tr>
<td>Severe vomiting</td>
<td>Seizure</td>
</tr>
<tr>
<td>CHF</td>
<td>Coma</td>
</tr>
<tr>
<td>Renal f/ins</td>
<td>Hypotension</td>
</tr>
<tr>
<td>Cushing’s syndrome</td>
<td>Tachycardia</td>
</tr>
<tr>
<td>Diabetes</td>
<td>Weak pulse</td>
</tr>
<tr>
<td></td>
<td>Decreased urine output</td>
</tr>
</tbody>
</table>

Sodium
Hyponatremia Na+ < 135 mEq/L

<table>
<thead>
<tr>
<th>Causes</th>
<th>Presents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diuretic use</td>
<td>Headache</td>
</tr>
<tr>
<td>GI loss</td>
<td>Lethargy</td>
</tr>
<tr>
<td>Burns/wounds</td>
<td>Decreased reflexes</td>
</tr>
<tr>
<td>Hypotonic IV use</td>
<td>Nausea vomiting</td>
</tr>
<tr>
<td>Cirrhosis</td>
<td>Diarrhea</td>
</tr>
<tr>
<td></td>
<td>Seizure</td>
</tr>
<tr>
<td></td>
<td>Coma</td>
</tr>
<tr>
<td></td>
<td>Orthostatic hypotension</td>
</tr>
<tr>
<td></td>
<td>Pitting edema</td>
</tr>
</tbody>
</table>

Potassium

![Diagram of potassium ions entering and exiting the cell](image)

- Phase 0, Na⁺ enters the cell, depolarization
- Phase 2, Ca²⁺ enters the cell, indication of contraction
- Phase 3, K⁺ exits the cell, repolarization
- Resting Potential

Depolarization _________ Repolarization _________
Potassium
Hyperkalemia K+ > 5.3 mEq/L

<table>
<thead>
<tr>
<th>Causes</th>
<th>Presents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renal failure</td>
<td>Muscle weakness/paralysis</td>
</tr>
<tr>
<td>Metabolic acidosis</td>
<td>Paresthesia</td>
</tr>
<tr>
<td>DKA</td>
<td>Bradycardia</td>
</tr>
<tr>
<td>Addison's disease</td>
<td>Heart Block</td>
</tr>
<tr>
<td>Excesses K supplements</td>
<td>V-fib</td>
</tr>
<tr>
<td>Blood transfusions</td>
<td>Cardiac arrest</td>
</tr>
</tbody>
</table>

Potassium
Hypokalemia K+ < 3.0 mEq/L

<table>
<thead>
<tr>
<th>Causes</th>
<th>Presents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diarrhea/vomiting</td>
<td>Extremity weakness</td>
</tr>
<tr>
<td>GI losses/NG suction</td>
<td>Hyporeflexia</td>
</tr>
<tr>
<td>Diuretics</td>
<td>Paresthesia</td>
</tr>
<tr>
<td>Cushing Syndrome</td>
<td>Leg Cramps</td>
</tr>
<tr>
<td>Malnutrition</td>
<td>ECG changes</td>
</tr>
<tr>
<td>Restrictive diets</td>
<td>ST depression</td>
</tr>
<tr>
<td>ETOH abuse</td>
<td>Inverted Ts</td>
</tr>
<tr>
<td></td>
<td>Cardiac arrest</td>
</tr>
<tr>
<td></td>
<td>Hypotension</td>
</tr>
<tr>
<td></td>
<td>Constipation</td>
</tr>
</tbody>
</table>
Hypercalcemia Ca++ > 11 mg/dL

Causes
- Excessive Ca supplements/antacids
- Bone destruction –tumor, immobilization, fracture
- Excess vitamin D
- Cancer
- Renal failure

Presents
- Ventricular dysrhythmias
- Heart block
- Asystole
- Coma
- Lethargy
- Muscle weakness
- Decreased reflexes
- Constipation
- Nausea/vomiting
Calcium
Hypocalcemia Ca++ < 8.5 mg/dL

<table>
<thead>
<tr>
<th>Causes</th>
<th>Presents</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETOH abuse</td>
<td>Anxiety</td>
</tr>
<tr>
<td>Poor dietary intake</td>
<td>Confusion</td>
</tr>
<tr>
<td>Limited GI absorption</td>
<td>Agitation</td>
</tr>
<tr>
<td>Pancreatitis</td>
<td>Seizure</td>
</tr>
<tr>
<td>Laxative use</td>
<td>Prolonged QT interval</td>
</tr>
<tr>
<td></td>
<td>Fatigue</td>
</tr>
<tr>
<td></td>
<td>Numbness/tingling</td>
</tr>
<tr>
<td></td>
<td>Hyperreflexia</td>
</tr>
<tr>
<td></td>
<td>Muscle cramps</td>
</tr>
</tbody>
</table>

Phosphate

Hypophosphatemia < 2.4 mg/dL
- Same as hypocalcemia

Hyperphosphatemia > 4.8 mg/dL
- Same as hypercalcemia

Chloride
Hyperchloremia > 110 mEq/L

<table>
<thead>
<tr>
<th>Cause</th>
<th>Presents</th>
</tr>
</thead>
<tbody>
<tr>
<td>High salt low water diet</td>
<td>Lethargy</td>
</tr>
<tr>
<td>Hypertonic IV</td>
<td>Decreases level of consciousness</td>
</tr>
<tr>
<td>Metabolic Acidosis</td>
<td>Weakness</td>
</tr>
<tr>
<td>Renal Failure</td>
<td>Edema</td>
</tr>
<tr>
<td></td>
<td>Tachypnea</td>
</tr>
<tr>
<td></td>
<td>HTN</td>
</tr>
<tr>
<td></td>
<td>Tachycardia</td>
</tr>
</tbody>
</table>
### Chloride
#### Hypochloremia < 104 mEq/L

<table>
<thead>
<tr>
<th>Causes</th>
<th>Presents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low salt diet</td>
<td>Agitation</td>
</tr>
<tr>
<td>Water intoxication</td>
<td>Irritability</td>
</tr>
<tr>
<td>Diuresis</td>
<td>Hypertonicity</td>
</tr>
<tr>
<td>Excessive vomiting/diarrhea</td>
<td>Hyperreflexia</td>
</tr>
<tr>
<td></td>
<td>Cramping</td>
</tr>
<tr>
<td></td>
<td>Twitching</td>
</tr>
</tbody>
</table>

### Magnesium
#### Hypermagnesemia > 2.7mEq/L

<table>
<thead>
<tr>
<th>Causes</th>
<th>Presents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased intake</td>
<td>Diaphoresis</td>
</tr>
<tr>
<td>• Antacids</td>
<td>Nausea/vomiting</td>
</tr>
<tr>
<td>• Mag-citrate</td>
<td>Drowsiness</td>
</tr>
<tr>
<td>Renal failure</td>
<td>Lethargy</td>
</tr>
<tr>
<td>Leukemia</td>
<td>Weakness/flaccidity</td>
</tr>
<tr>
<td>Dehydration</td>
<td>Decreased DTR</td>
</tr>
<tr>
<td></td>
<td>Hypotension</td>
</tr>
<tr>
<td></td>
<td>Heart block</td>
</tr>
</tbody>
</table>

### Magnesium
#### Hypomagnesemia < 1.8 mEq/L

<table>
<thead>
<tr>
<th>Causes</th>
<th>Presents</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETOH</td>
<td>Hyperreflexia</td>
</tr>
<tr>
<td>Eating disorders</td>
<td>Tremors</td>
</tr>
<tr>
<td>Diuresis</td>
<td>Spasticity</td>
</tr>
<tr>
<td>DKA</td>
<td>Seizures</td>
</tr>
<tr>
<td>Medications</td>
<td>Nystagmus</td>
</tr>
<tr>
<td></td>
<td>Prolonged PR/QT intervals</td>
</tr>
<tr>
<td></td>
<td>PVC, VT, VF</td>
</tr>
<tr>
<td></td>
<td>Emotional lability</td>
</tr>
</tbody>
</table>
### BUN

**Blood Urea Nitrogen**

| Urea forms in the liver from breakdown of proteins and aminos. |
| Normal ranges 10-20 mg/dL |
| Used to measure renal excretory capacity, estimate protein catabolism and tissue necrosis |
| • High: High protein diet, renal failure, hypovolemia, CHF, GI Bleed, fever, increased protein catabolism |
| • Low: liver disease |

### Creatinine

| Constant excretion each day dependent on body muscle mass |
| Increased levels consistent with renal disease |
| Normal Range: 0.9-1.3 mg/dL |
| Other causes of increased levels |
| • Muscular Dystrophy |
| • Myasthenia Gravis |
| • Rhabdomyolysis |
| • Dehydration |

### Cardiac Specific Testing
Brain Natriuretic Peptide (BNP)

- Named prior to discovery that it exists in the left ventricle of the heart
- As blood volume increases so do BNP levels thought to be caused by stretching of the walls.

<table>
<thead>
<tr>
<th>BNP (pg/mL)</th>
<th>NYHA Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 100</td>
<td>No risk of heart failure</td>
</tr>
<tr>
<td>100-300</td>
<td>Class I – Cardiac disease, but no symptoms and no limitation in ordinary physical activity</td>
</tr>
<tr>
<td>100-300</td>
<td>Class II – Mild symptoms (e.g., shortness of breath when walking, climbing stairs, etc.)</td>
</tr>
<tr>
<td>&gt; 300</td>
<td>Class III – Marked limitation in activity due to symptoms, even during less-than-ordinary activity, e.g., walking short distances (20–100 m). Comfortable only at rest</td>
</tr>
<tr>
<td>&gt; 600</td>
<td>Class IV – Severe limitation. Experiences symptoms even while at rest</td>
</tr>
</tbody>
</table>


Creatinine Kinase (CK)

Normal = 30-170 IU/L

Cytoplasmic Enzyme of Muscle- 3 forms

CK initiates the conversion of creatinine and utilizes adenosine triphosphate (ATP) to create phosphocreatine (PCr) and adenosine diphosphate (ADP).

- Skeletal muscle (MM)- 90% total CK
- Brain (BB)
- Cardiac Muscle (MB)
CK-MB

Commonly elevated in myocardial infarction within 3-6 hours of cardiac injury and then returns to normal within 2-3 days (peaks 18-24 hours)

Troponin

Troponin I binds to actin in thin myofilaments to hold the troponin-tropomyosin complex in place. Troponin T binds to tropomyosin, interlocking them to form a troponin-tropomyosin complex (N < 0.03 ng/mL)
Cardiac Specific Testing

Lipid Profile

Cholesterol metabolized by the liver to free form which is transported in the bloodstream by lipoproteins

- LDL - low-density lipoproteins
- HDL - high density lipoproteins
- Total Cholesterol
  - Approx 75% LDL + 25% HDL

Altering HDL/LDL Levels

- Genetics
- Smoking
- Diet
- Medications - oral contraceptives, sulfonamides, aspirin, steroids
- Hypothyroid
- Exercise
- ETOH
HDL/LDL

- HDL: Good cholesterol, helps remove cholesterol from the body.
- LDL: Bad cholesterol, can lead to heart disease.
- HDL/LDL ratio: Healthy if HDL > LDL.
- HDL/LDL ratio: Unhealthy if HDL < LDL.

Triglycerides

- Fat converted to:
  - Glycerol
  - Free fatty acids
  - Monoglycerides

Lipid Profile

<table>
<thead>
<tr>
<th>Test</th>
<th>Target Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDL</td>
<td>50-150 mg/dL</td>
</tr>
<tr>
<td>LDL</td>
<td>100-199 mg/dL</td>
</tr>
<tr>
<td>LDL (HDL)</td>
<td>40-160 mg/dL</td>
</tr>
<tr>
<td>Total Cholesterol</td>
<td>200-239 mg/dL</td>
</tr>
<tr>
<td>Triglycerides</td>
<td>50-150 mg/dL</td>
</tr>
</tbody>
</table>

- Target Ranges:
  - Low risk: LDL < 100 mg/dL, HDL > 60 mg/dL
  - Borderline High: LDL 100-129 mg/dL, HDL 40-59 mg/dL
  - High Risk: LDL 130-159 mg/dL, HDL < 40 mg/dL
  - Very High Risk: LDL > 160 mg/dL, HDL < 35 mg/dL

References:
- Goodman (2015)
Other Cardiac Markers

Homocystein

Amino acid produced by breakdown of protein.

High levels linked to:
- Alzheimer’s
- HTN
- Risk for stroke

- 5-15 µmol/L Normal
- 16-100 µmol/L Mild
- >100 µmol/L Severe

C-reactive protein (CRP)

Hs-CRP (high sensitivity CRP)
- Produced by liver
- Response to presence of inflammation
- Systemic inflammation linked to atherosclerosis
- Indicate risk for MI and stroke
- 50% MI and CVA occur with normal cholesterol levels
- Low LDL but High CRP = increased CV events

<table>
<thead>
<tr>
<th>Hs-CRP (µmol/L)</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1</td>
<td>Low</td>
</tr>
<tr>
<td>1-3</td>
<td>Average</td>
</tr>
<tr>
<td>&gt;3</td>
<td>High</td>
</tr>
</tbody>
</table>

Arterial Blood Gas
### Acid Base Balance

<table>
<thead>
<tr>
<th>Acid Base Balance</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Respiratory Acidosis</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Respiratory Alkalosis</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Metabolic Acidosis</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Metabolic Alkalosis</strong></td>
<td></td>
</tr>
</tbody>
</table>

The ratio of HCO3/PaCO2 effects pH
Normal Blood pH 7.35-7.45

---

### Acid Base Balance

<table>
<thead>
<tr>
<th>Acid Base Balance</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Respiratory Acidosis</strong></td>
<td></td>
</tr>
</tbody>
</table>

Condition caused by hypoventilation of the alveoli leading to increased arterial carbon dioxide (PaCO2)
Blood pH < 7.35

---

### Acid Base Balance

<table>
<thead>
<tr>
<th>Acid Base Balance</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Respiratory Acidosis</strong></td>
<td></td>
</tr>
</tbody>
</table>

Hypercapnia
Hypoventilation
Headache
Visual Disturbances
Confusion
Drowsiness
Depressed Tendon Reflexes
Hyperkalemia
Ventricular Fibrillation- caused by hyperkalemia
<table>
<thead>
<tr>
<th>Acid Base Balance</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Respiratory Alkalosis</strong></td>
<td></td>
</tr>
<tr>
<td>Condition caused by hyperventilation of the alveoli leading to decreased plasma carbon dioxide concentration (pCO₂)</td>
<td></td>
</tr>
<tr>
<td>Blood pH &gt; 7.45</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Acid Base Balance</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Respiratory Alkalosis</strong></td>
<td></td>
</tr>
<tr>
<td>Hypocapnia</td>
<td></td>
</tr>
<tr>
<td>Lightheadedness</td>
<td></td>
</tr>
<tr>
<td>Numbness/tingling of digits</td>
<td></td>
</tr>
<tr>
<td>Hypocalcaemia</td>
<td></td>
</tr>
<tr>
<td>Hypokalemia</td>
<td></td>
</tr>
<tr>
<td>Cardiac Dysrhythmias secondary Hypokalemia</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Acid Base Balance</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Metabolic Acidosis</strong></td>
<td></td>
</tr>
<tr>
<td>Bicarbonate deficit</td>
<td></td>
</tr>
<tr>
<td>Hyperventilation</td>
<td></td>
</tr>
<tr>
<td>Headache</td>
<td></td>
</tr>
<tr>
<td>Hyperkalemia</td>
<td></td>
</tr>
<tr>
<td>Stupor</td>
<td></td>
</tr>
</tbody>
</table>
Acid Base Balance

Metabolic Acidosis

Primary cause is a process in which the body is not able to form bicarbonate in the kidney.
Blood pH <7.35

Metabolic Acidosis

A Mnemonic can also be used - MUDPILES

M - Methanol
U - Uremia (chronic kidney failure)
D - Diabetic ketoacidosis
P - Propylene glycol
I - Infection, Iron, Isoniazid, Inborn errors of metabolism
L - Lactic acidosis
E - Ethylene glycol / Ethanol
S - Salicylates

Acid Base Balance

Metabolic Alkalosis

Condition in which there is an increase in bicarbonate production.
Blood pH >7.45
Acid Base Balance

Metabolic Alkalosis
- Bicarbonate Excess
- Hypoventilation
- Confusion
- Dizziness
- Hypokalemia
- Convulsions

Anion Gap
- The difference between free cations (+) and free anions (-).
- The major free cations are Sodium (Na+) and Potassium (K+).
- The major anions are Chloride (Cl-) and Bicarbonate (HCO₃-)
- Reference Value- 8 to 10 mEq

The anion gap (AG) is calculated from the equation

\[ AG = [(Na^+) + (K^+)] - [(Cl^-) + (HCO_3^-)] \]

Anion Gap- Clinical Considerations

- Elevated Anion Gap
  - Uncontrolled diabetes-Increased ketoacids
  - Methanol intoxication- Increased formic acid
  - Tissue hypoxia-Increased lactic acid

- Clinical Decisions: use a systems based approach based on the cause of the elevated AG level not the value itself.
### Components of the Arterial Blood Gas

**pH**

Measurement of acidity or alkalinity, based on the hydrogen (H+) ions present.

The normal range is 7.35 to 7.45

- pH > 7.45 = alkalosis
- pH < 7.35 = acidosis

### Components of the Arterial Blood Gas

**PO2**

The partial pressure of oxygen that is dissolved in arterial blood.

The normal range is 80 to 100 mm Hg

### Components of the Arterial Blood Gas

**SaO2**

The arterial oxygen saturation.

The normal range is 95% to 100%.
Components of the Arterial Blood Gas

\textbf{pCO2}

The amount of carbon dioxide dissolved in arterial blood.

The normal range is 35 to 45 mm Hg.

\begin{itemize}
  \item pCO2 > 45 = acidosis
  \item pCO2 < 35 = alkalosis
\end{itemize}

Components of the Arterial Blood Gas

\textbf{HCO3}

The calculated value of the amount of bicarbonate in the bloodstream.

The normal range is 22 to 26 mEq/liter

\begin{itemize}
  \item HCO3 > 26 = alkalosis
  \item HCO3 < 22 = acidosis
\end{itemize}

Components of the Arterial Blood Gas

\textbf{B.E.}

The base excess indicates the amount of excess or insufficient level of bicarbonate in the system.

The normal range is –2 to +2 mEq/liter.

Remember:
A negative base excess indicates a base deficit in the blood.
## Let's Try It

### Step One
Identify whether the pH, pCO2 and HCO3 are abnormal. For each component, label it as "normal", "acid" or "alkaline".

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.50</td>
<td>(7.35-7.45)</td>
</tr>
<tr>
<td>pCO2</td>
<td>42</td>
<td>(35-45)</td>
</tr>
<tr>
<td>HCO3</td>
<td>33</td>
<td>(22-26)</td>
</tr>
</tbody>
</table>

### Step One

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
<th>Range</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.50</td>
<td>(7.35-7.45)</td>
<td>ALKALINE</td>
</tr>
<tr>
<td>pCO2</td>
<td>42</td>
<td>(35-45)</td>
<td>NORMAL</td>
</tr>
<tr>
<td>HCO3</td>
<td>33</td>
<td>(22-26)</td>
<td>ALKALINE</td>
</tr>
</tbody>
</table>
### Step Two

If the ABG results are abnormal, determine if the abnormality is due to the kidneys (metabolic) or the lungs (respiratory).

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
<th>Normal Range</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.50</td>
<td>(7.35-7.45)</td>
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</tr>
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<tr>
<td>HCO3</td>
<td>33</td>
<td>(22-26)</td>
<td>ALKALINE</td>
</tr>
</tbody>
</table>

### Step Two

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
<th>Normal Range</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.50</td>
<td>(7.35-7.45)</td>
<td>ALKALINE</td>
</tr>
<tr>
<td>PaCO2</td>
<td>42</td>
<td>(35-45)</td>
<td>NORMAL = Lungs</td>
</tr>
<tr>
<td>HCO3</td>
<td>33</td>
<td>(22-26)</td>
<td>ALKALINE = Kidneys</td>
</tr>
</tbody>
</table>

Match the two abnormalities: Kidneys (metabolic) + Alkalosis = **Metabolic Alkalosis**

### Step One

Identify whether the pH, pCO2 and HCO3 are abnormal. For each component, label it as “normal”, “acid” or “alkaline”.

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
<th>Normal Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.31</td>
<td>(7.35-7.45)</td>
</tr>
<tr>
<td>pCO2</td>
<td>39</td>
<td>(35-45)</td>
</tr>
<tr>
<td>HCO3</td>
<td>17</td>
<td>(22-26)</td>
</tr>
</tbody>
</table>
## Step One

Identify whether the pH, pCO2 and HCO3 are abnormal. For each component, label it as “normal”, “acid” or “alkaline.”

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
<th>Normal Range</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.31</td>
<td>7.35-7.45</td>
<td>Acidosis</td>
</tr>
<tr>
<td>PaCO2</td>
<td>39</td>
<td>35-45</td>
<td>Normal</td>
</tr>
<tr>
<td>HCO3</td>
<td>17</td>
<td>22-26</td>
<td>Acidosis</td>
</tr>
</tbody>
</table>

## Step Two

If the ABG results are abnormal, determine if the abnormality is due to the kidneys (metabolic) or the lungs (respiratory).

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
<th>Normal Range</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.31</td>
<td>7.35-7.45</td>
<td>Acidosis</td>
</tr>
<tr>
<td>PaCO2</td>
<td>39</td>
<td>35-45</td>
<td>Normal</td>
</tr>
<tr>
<td>HCO3</td>
<td>17</td>
<td>22-26</td>
<td>Acidosis</td>
</tr>
</tbody>
</table>

**Step Two**

- pH 7.31 (7.35-7.45) ACIDOSIS
- PaCO2 39 (35-45) NORMAL = lungs
- HCO3 17 (22-26) ACIDOSIS = kidneys

Match the two abnormalities: Kidneys (metabolic) + Acidosis = **Metabolic Acidosis**
Compensation

- Patient develops an acid-base imbalance
- The body attempts to compensate.
- The lungs and the kidneys are the primary buffer response systems
- The body tries to overcome a respiratory or metabolic dysfunction in an attempt to return the pH into the normal range.

Compensation

- When an acid-base disorder is either uncompensated or partially compensated, the pH remains outside the normal range
- In fully compensated states, the pH has returned to within the normal range, although the other values may still be abnormal.
- Neither system has the ability to overcompensate

Compensation

<table>
<thead>
<tr>
<th>pH</th>
<th>7.38</th>
<th>(7.35-7.45)</th>
<th>NORMAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>PaCO2</td>
<td>56</td>
<td>(35-45)</td>
<td>ACIDOSIS</td>
</tr>
<tr>
<td>HCO3</td>
<td>35</td>
<td>(22-26)</td>
<td>ALKALOSIS</td>
</tr>
</tbody>
</table>
Both the pCO2 and the HCO3 are abnormal
The pH is in the normal range,
Look at the pH again- Instead of using a “normal range”
of 7.35-7.45 as we have been doing, we are going to
use the single value of 7.4 as our only “normal”.
Any pH of <7.40 is now going to be considered acidosis.
Any pH > 7.40 is now going to be considered alkalosis.

<table>
<thead>
<tr>
<th>Compensation</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH 7.38 (7.4) ACIDOSIS</td>
</tr>
<tr>
<td>PaCO2 56 (35-45) ACIDOSIS</td>
</tr>
<tr>
<td>HCO3 35 (22-26) ALKALOSIS</td>
</tr>
</tbody>
</table>

Match the two abnormalities: Respiratory (lungs) + Acidosis = Respiratory Acidosis
**Compensation**

- If the pH is between 7.35-7.45, the condition is fully *compensated*.
- If the pH is outside the range of 7.35-7.45, the condition is only partially *compensated*.
- Remember, neither buffer system has the ability to *overcompensate*!

Because the pH is 7.38 (within the range of 7.35-7.45), the condition is fully compensated. Final arterial blood gas analysis indicates that we have a *Compensated Respiratory Acidosis*.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Normal Range</th>
<th>Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.38</td>
<td>(7.4)</td>
<td>ACIDOSIS</td>
</tr>
<tr>
<td>PaCO2</td>
<td>56</td>
<td>(35-45)</td>
<td>ACIDOSIS = Lungs</td>
</tr>
<tr>
<td>HCO3</td>
<td>35</td>
<td>(22-26)</td>
<td>ALKALOSIS</td>
</tr>
</tbody>
</table>

---

**Special and Disease Specific Tests**
Carbohydrate Metabolism Tests

- Glucose
- Hgb A1C (Glycosylated hemoglobin)

Glucose
Normal fasting 70-100 mg/dL

Measure of blood glucose at the time sample was obtained.
- Random plasma
- Fasting Plasma Glucose (FPG)
- Oral glucose tolerance test

Criteria for diagnosis of Diabetes
- FPG >126 mg/dL OR
- 2 hour Plasma Glucose >200 mg/dL

Glucose Uptake in the Body

Normal
- Insulin enters bloodstream from pancreas
- Glucose enters bloodstream from pancreas
- Healthy balance of glucose and insulin circulates in bloodstream
- Insulin leaves bloodstream and binds to cell
- Glucose cannot enter cell

Diabetes
- Insulin leaves bloodstream from pancreas
- Glucose enters bloodstream from digestive system and tree
- Unhealthy amount of glucose circulates in bloodstream
- Insulin leaves bloodstream and binds to cell
- Glucose cannot enter cell
- The cell has less glucose for fuel
**Glucose- Hyperglycemia** (> 200 mg/dL)

<table>
<thead>
<tr>
<th>Causes</th>
<th>Presentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetes mellitus</td>
<td>DKA</td>
</tr>
<tr>
<td>Sepsis</td>
<td>Severe Fatigue</td>
</tr>
<tr>
<td>Brain Tumors</td>
<td></td>
</tr>
<tr>
<td>Certain medications</td>
<td></td>
</tr>
<tr>
<td>High dose steroids</td>
<td></td>
</tr>
<tr>
<td>IV glucose</td>
<td></td>
</tr>
<tr>
<td>After a meal*</td>
<td></td>
</tr>
<tr>
<td>Cushing's disease*</td>
<td></td>
</tr>
<tr>
<td>Pancreatitis</td>
<td></td>
</tr>
</tbody>
</table>

**Glucose- Hypoglycemia** (< 70 mg/dL)

<table>
<thead>
<tr>
<th>Causes</th>
<th>Presentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excess insulin</td>
<td>Headache*</td>
</tr>
<tr>
<td>Brain injury</td>
<td>Fatigue*</td>
</tr>
<tr>
<td>Pituitary deficiency</td>
<td>Lethargy*</td>
</tr>
<tr>
<td>(hypothyroidism)</td>
<td>Hunger*</td>
</tr>
<tr>
<td>Malignancy</td>
<td>Tachycardia*</td>
</tr>
<tr>
<td>Addison's disease</td>
<td>Irritability</td>
</tr>
<tr>
<td>Presence of benign insulin-producing tumor*</td>
<td>Shaking/tremor*</td>
</tr>
<tr>
<td>Starvation*</td>
<td>Extremity Weakness</td>
</tr>
<tr>
<td></td>
<td>Sweating*</td>
</tr>
<tr>
<td></td>
<td>Anxiety/Confusion*</td>
</tr>
<tr>
<td></td>
<td>Loss of consciousness</td>
</tr>
</tbody>
</table>

**Implications of Altered Glucose**

- Decreased tolerance to activity
- May not tolerate therapy until glucose level increased
- A glucose target between 140-180 mg/dL is recommended for most patients in noncritical care units while hospitalized
- Check for most recent glucose levels (before/after exercise if outpatient)
- If levels are low, they may need food.
- Check facility policy if levels high, may be able to exercise if asymptomatic
Clinical Signs and Symptoms of Untreated or Uncontrolled Diabetes

- Polyuria
- Polydipsia
- Polyphagia
- Weight loss
- Hyperglycemia (fasting > 126 mg/dL)
- Glycosuria
- Ketonuria
- Fatigue and weakness
- Blurred vision
- Poor wound healing and recurrent infections

Strategies for Management of Blood Glucose During/After Exercise

- Reduce pre-exercise bolus insulin
- Reduce pre-exercise basal insulin
- Take extra carbohydrate with exercise
- Pre-exercise or post exercise sprint
- Insulin pump therapy
- Reduce basal insulin post exercise

Hgb A1C (Glycosylated hemoglobin)

Hgb A1C Test used to look at long term blood glucose levels

- Glucose will stay attached to hemoglobin for 120 days so information is regarding blood glucose levels for past 2-3 months
- ↑ levels indicate poorly controlled DM
**Hgb A1C (Normal < 5.7% )**

| Normal: < 5.7%  |
|-----------------|-----------------|
| • Pre-diabetes mellitus: 5.7 - 6.4%  |
| • With diabetes mellitus: > 6.5% (poor glucose control) |

**Hgb A1C**

<table>
<thead>
<tr>
<th>Causes</th>
<th>Presentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetes mellitus</td>
<td>Eye disease</td>
</tr>
<tr>
<td></td>
<td>Heart disease</td>
</tr>
<tr>
<td></td>
<td>Kidney disease</td>
</tr>
<tr>
<td></td>
<td>Nerve damage</td>
</tr>
<tr>
<td></td>
<td>Stroke</td>
</tr>
<tr>
<td></td>
<td>Gum disease</td>
</tr>
<tr>
<td></td>
<td>Non-traumatic amputations</td>
</tr>
</tbody>
</table>

**Implications of Altered Hgb A1C**

- Monitor vitals as a standard of care
- Educate importance of exercise for blood sugar control.
- Consider wound-care management if levels altered
Patient Case

Importance of Hepatic Function

- Protein synthesis
- Storage
- Nutrient metabolism
- Blood Glucose regulation
- Bile drainage
- Blood circulation and filtration
- Detoxification

Hepatic Function Tests

Assesses the liver’s ability to clear bilirubin, total protein, and albumin

- Serum Albumin
- Serum Pre-Albumin
- Ammonia (NH3)
- Serum Bilirubin
- Liver Enzymes
Serum Albumin and Serum Prealbumin

**Serum Albumin**: 3.5-5.2 g/dL
- Half-life of 21 days
- Required for proper distribution of body fluids between intravascular compartments & body tissues.
- Transports thyroid, other hormones and drugs & buffers pH

**Serum Prealbumin**: 19-39 mg/dL
- Half-life of 2 days
- Detects current nutritional status within a patient's body

---

**Albumin**

---

**Serum Pre-albumin and Nutritional Status**

<table>
<thead>
<tr>
<th>Prealbumin Level</th>
<th>Protein Depletion</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5 mg/dL</td>
<td>Severe</td>
</tr>
<tr>
<td>5-10 mg/dL</td>
<td>Moderate</td>
</tr>
<tr>
<td>10-15 mg/dL</td>
<td>Mild</td>
</tr>
</tbody>
</table>
### Serum Albumin and Pre-albumin Trending Upward

<table>
<thead>
<tr>
<th>Causes</th>
<th>Presentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nutritional compromise</td>
<td>Clinical features are dependent on the cause</td>
</tr>
<tr>
<td>Severe infections</td>
<td>• i.e. renal, cardiac, TB, etc.</td>
</tr>
<tr>
<td>Congenital disorders</td>
<td>• Systemic peripheral edema</td>
</tr>
<tr>
<td>Severe dehydration</td>
<td>• Delayed wound healing</td>
</tr>
<tr>
<td>Hepatitis</td>
<td></td>
</tr>
<tr>
<td>Chronic inflammation</td>
<td></td>
</tr>
<tr>
<td>Tuberculosis</td>
<td></td>
</tr>
<tr>
<td>Overdose of cortisone medications</td>
<td></td>
</tr>
<tr>
<td>CHF</td>
<td></td>
</tr>
<tr>
<td>Renal Disease</td>
<td></td>
</tr>
<tr>
<td>Cancer</td>
<td></td>
</tr>
</tbody>
</table>

### Serum Albumin and Pre-albumin Trending Downward

<table>
<thead>
<tr>
<th>Causes</th>
<th>Presentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infection</td>
<td>Peripheral edema</td>
</tr>
<tr>
<td>Inflammation</td>
<td>Non-healing wound</td>
</tr>
<tr>
<td>Liver disease</td>
<td>Hypotension</td>
</tr>
<tr>
<td>Kidney disease</td>
<td></td>
</tr>
<tr>
<td>Crohn's disease</td>
<td></td>
</tr>
<tr>
<td>Burns</td>
<td></td>
</tr>
<tr>
<td>Malnutrition/malabsorption</td>
<td></td>
</tr>
<tr>
<td>Thyroid disease</td>
<td></td>
</tr>
</tbody>
</table>

### Hypoalbuminemia

<table>
<thead>
<tr>
<th>Albumin levels</th>
<th>Serum Prealbumin</th>
</tr>
</thead>
<tbody>
<tr>
<td>• &lt; 3.0 g/dL nutritionally compromised</td>
<td>19-39 mg/dL</td>
</tr>
<tr>
<td>• &lt; 2.8 g/dL peripheral edema, poor wound healing</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Clinical Implications</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Assess integumentary (incisions) daily</td>
<td></td>
</tr>
<tr>
<td>• Collaborate with the interdisciplinary team regarding nutrition</td>
<td></td>
</tr>
</tbody>
</table>
Ammonia (NH₃) 15-60 µg/dL

Ammonia:

Used to evaluate liver function and metabolism.
- Results from breakdown of protein in the body.

The liver converts ammonia from blood to urea.
- If the liver is damaged, then increased ammonia levels are noted.

Ammonia and Metabolism

Ammonia Trending Upward

**Causes**
- Cirrhosis
- Severe hepatitis
- Reye's syndrome
- Severe heart disease
- Kidney failure
- Severe bleeding of stomach or intestines (GI Problems)

**Presentation**
- Hepatic encephalopathy
- Confusion
- Lethargy
- Dementia
- Daytime sleepiness
- Tremors
- Breakdown of fine motor skills
- Numbness and tingling (peripheral nerve impaired)
- Speech impairment

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Ammonia (NH₃) 15-60 µg/dL

**Clinical Implications**
- May need to alter communication and education, and designate patient as an increased fall risk, if encephalopathy present
- Clinically you can see confusion, fatigue, muscle weakness, numbness and tingling, some peripheral nerve symptoms
- If levels get too high get encephalopathy and coma/death.

Serum Bilirubin 0.3-1.0 mg/dL

**Bilirubin**
- Used to look at liver function
- Found in the bile which is produced by the liver
- Can be measured by a blood test or with a urine test.

Bilirubin Metabolism
Serum Bilirubin Trending Upward

**Causes**
- Cirrhosis
- Hepatitis
- Liver metastasis
- Hemolytic anemia
- Jaundice
- Transfusion reaction
- Bile duct occlusion
- Gallstones
- Chemotherapy

**Presentation**
- Patients with severe disease might have fatigue, anorexia, nausea, fever, and, occasionally, vomiting.
- Might have loose, fatty stools.
- Patients with high levels of bilirubin can lead to jaundice.

Serum Bilirubin

Clinical Implications:
- Adapt education if decreased cognition.
- Patients with advanced disease are at risk for osteoporosis and bleeding due to deficiencies of fat soluble vitamins.
- Symptoms-based approach when determining appropriateness for activity

Model for End-Stage Liver Disease (MELD) and MELD-Na

<table>
<thead>
<tr>
<th>MELD Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serum bilirubin</td>
</tr>
<tr>
<td>Serum creatinine</td>
</tr>
<tr>
<td>INR</td>
</tr>
<tr>
<td>MELD-Na</td>
</tr>
<tr>
<td>Serum bilirubin</td>
</tr>
<tr>
<td>Serum creatinine</td>
</tr>
<tr>
<td>INR</td>
</tr>
<tr>
<td>Sodium</td>
</tr>
</tbody>
</table>
Model for End-Stage Liver Disease (MELD) and MELD-Na

<table>
<thead>
<tr>
<th>MELD Score and 3 Month Mortality</th>
<th>Mortality Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>40 or more</td>
<td>71.3%</td>
</tr>
<tr>
<td>30–39</td>
<td>52.6%</td>
</tr>
<tr>
<td>20–29</td>
<td>19.6%</td>
</tr>
<tr>
<td>10–19</td>
<td>6.0%</td>
</tr>
<tr>
<td>&lt; 9</td>
<td>1.9%</td>
</tr>
</tbody>
</table>

Liver Enzymes

- **Alanine aminotransferase (ALT)**- found in cells of liver and kidney
  - Released with liver damage
  - Useful in detecting damage related to hepatitis and/or drugs
- **Aspartate aminotransferase (AST)**- found in liver/heart/muscle cells
  - Useful in detecting damage due to hepatitis, cirrhosis, drugs toxic to liver (hepatoxic), alcoholism
- **Alkaline phosphatase (ALP)**- found in cells of bile ducts and bones
  - Useful in detecting blockage of bile ducts, hepatitis, liver cancer, cirrhosis or hepatoxic drugs
Clinical Bottom Line

Red Flags for liver dysfunction include:

- Altered cognition or mental status
- Ascites
- Peripheral edema
- Musculoskeletal pain
- Right Upper abdominal pain
- Weakness
- Fatigue

We must alter our communication, document changes/inform medical team, be aware of safety risks, and involve caregivers.

Patient Case

FK Trough (6-15 ng/mL)

- Also known as the Tacrolimus/Prograf Test
- Used to measure the amount of drug in the blood to determine whether concentration has reached therapeutic levels or is below toxic amounts.

- Tacrolimus is a highly effective immunosuppressant for lowering the risk of organ transplantation.
  - The drug is essentially fully metabolized in the liver and intestinal wall, with multiple factors affecting the pharmokinetic and metabolic profile (age, sex, other organ impairment, diet, and concomitant medications).
 FK Trough Considerations

- Physical therapists should review FK trough (Tacrolimus/Prograf test) to assess for trends (spikes) when evaluating patients for safe exercise prescription.

FK Trough Considerations

- While dosing is being established by the physician, patients might show the following with increasing trends:
  - tremors
  - seizures
  - elevated heart rate
  - hypertension
  - blurred vision
  - nausea and vomiting
  - ataxia

Thyroid Function Tests

Thyroid Hormone role:
- Helps the body with metabolism, energy generation, temperature regulation, and mood.

Panel of tests:
- Thyroxine (T4)
- Triiodothyronine (T3)
- Free T4 Index
- Thyroid – Stimulating Hormone (TSH)
Thyroid Function Tests

Reference Ranges

- Thyroxine (T4)
  - 4.5-11.5 µg/dL
- Triiodothyronine (T3)
  - 80-200 ng/dL
- Free T4 Index
  - 4.6-11.2 ng/dL
- Thyroid Stimulating Hormone (TSH)
  - 0.3-3.0 mIU/L
- Increased TSH and decreased T4 = thyroid disease
- Decreased TSH = pituitary disease

Hyperthyroidism

(Increased T3 and/or T4)

Presentation:
- Tremors
- Nervousness/lability
- Weakness/muscular atrophy
- Increased reflexes
- Fatigue and difficulty sleeping
- Tachycardia – increased cardiac output
- Arrhythmias (atrial fibrillation)
- Hypotension
- Chronic periarthritic
- Proximal weakness
- Also affects: integumentary, gastrointestinal, genitourinary systems
Hypothyroidism
(Increased TSH, Decreased T3 or T4)

Presentation:
- Slow Speech/Hoarseness
- Slow Mental Function
- Ataxia
- Proximal muscle weakness
- Carpal tunnel syndrome
- Prolonged reflexes
- Paresthesia
- Muscular/joint edema

Hypothyroidism
(Increased TSH, Decreased T3 or T4)

Presentation (continued):
- Back pain
- Bradycardia
- CHF
- Poor peripheral circulation
- Hyperlipidemia
- HTN
- Also affects: integumentary, gastrointestinal and genitourinary systems

Implications of Hyperthyroidism

- Decreased exercise tolerance
  - both strength and capacity
- Monitor heart rate and blood pressure
- Patient at risk for dysrhythmias during exercise
- Patient in a hypermetabolic state will deplete nutrients quickly with exercise.
Implications of Hypothyroidism

- Hypothyroidism – frequently accompanied by myalgia and CK elevation
- More prone to skin tears
- Activity intolerance
  - should improve with treatment of hypothyroidism
- Rhabdomyolysis, although rare, can appear in the presence of heavy exercise, alcohol, or medications
- Monitor heart rate
  - bradycardia

Fluid Analysis and Pathology

- Useful to determine cause of fluid buildup
- Used to remove excess fluid
- May monitor pressures of fluid in spaces
- These results help determine the pathology leading to the presence of this fluid.
- Unlike other laboratory tests, patients may have precautions and restrictions immediately after this test (before results are available) impacting delivery of therapy services.

Thoracentesis

What is it?
A procedure to remove excess fluid in the space between the lungs and chest wall (aka the pleural space).

Pathology causing fluid accumulation (aka pleural effusion):
- tumors
- pneumonia
- thyroid disease
- chronic lung diseases
- congestive heart failure
- pulmonary embolism
PERICARDIOCENTESIS

What is it?
A procedure to remove fluid in the abdominal cavity (the area between the belly wall and the spine).

Pathology causing fluid accumulation:
- Liver cirrhosis
- Infection
- Kidney disease
- Heart disease
- Tumor
- Pancreatic disease

Paracentesis

What is it?
A procedure to remove fluid in the abdominal cavity (the area between the belly wall and the spine).

Pathology causing fluid accumulation:
- Liver cirrhosis
- Infection
- Kidney disease
- Heart disease
- Tumor
- Pancreatic disease

Lumbar Puncture

What is it?
A procedure to measure cerebrospinal fluid CSF; collect CSF for laboratory analysis, inject foreign substance (dye, medications), measure pressure of CSF

Pathology found with this test:
- cancers involving brain or spinal cord
- inflammatory conditions of nervous system
  -Guillain-Barre, Multiple Sclerosis
- subarachnoid hemorrhage
- bacterial, viral, fungal infections (meningitis)
Arthrocentesis

What is it?
A procedure to drain synovial fluid from a joint capsule.

Pathology found with this test:
• Gout
• Arthritis
• Synovial infection

Fluid Analysis-Considerations

Thoracentesis (Pleural fluid)
• Risk for pneumothorax—may want to listen to breath sounds
• Monitor heart rate and respiratory, look for dizziness, changes in skin color, anxiety, fever, restlessness, excessive coughing, blood tinged sputum, and tightness of the chest.
Pericardiocentesis
• Risk for cardiac tamponade
Paracentesis (Peritoneal fluid)
• Monitor vitals look for pallor, cyanosis, or dizziness

Fluid Analysis Considerations

Lumbar puncture (CSF—cerebral spinal fluid)
• At risk for spinal headache
• Watch for report of numbness or tingling in the lower extremities
• Drainage of blood or CSF at the puncture site
• May be on bedrest (period of time varies)

Arthrocentesis (Synovial fluid)
• Avoid strenuous use of joint for 48-72 hours
• Keep pressure dressing in place and apply ice
• Monitor for signs of infection—pain, fever, or swelling (i.e., indicators of infection)
Toxicology

What is it?
- Urine or blood sample test that determines type and amount of legal/illegal drugs taken by a patient.

Pathology found/ruled out with this test:
- Alcoholism and withdrawal
- Fetal alcohol syndrome
- Seizure
- Delirium and dementia
- Analgesic nephropathy
- Sexual assault

References