ACADEMY OF ACUTE CARE PHYSICAL THERAPY

# 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.

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## 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@yahoogroups.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
2002 Goodman et al, Pathology: Implication for the Physical Therapist, 2nd edition
2002, 2009 Paz J, West M, Acute Care Handbook for Physical Therapists
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
2006 Malone D, Physical Therapy in Acute Care: A clinicians guide. Thorofare, NJ.: SLACK Corporation.
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)*

2012 Frownfelter D, Dean E , C*ardiovascular and Pulmonary Physical Therapy Evidence and Practice* (5th ed.). St Louis: Elsevier-Mosby.

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

2015 Goodman C, Fuller K, *Pathology Implications for the physical therapist.* St Louis: Elsevier Saunders.

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.*

2016 Hillegass E, Puthoff M, Frese EM, et al. Role of Physical Therapists in the Management of Individuals at Risk for or Diagnosed With Venous Thromboembolism: Evidence-Based Clinical Practice Guideline. *Phys Ther.*.


## 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

- March April 2016
  - Prework including reference values for different institutions, top lab values needed for document
  - Identification of need for Point of Care document
- May 2016
  - 1st committee meeting and determination of framework for updated document
- Summer 2016
  - Monthly committee meetings and quick turnaround on assignments

## History of the Lab Resources Document

- August-Sept 2016
  - Completion of main document
  - Start of Point of Care document
- October 2016
  - Completion of Point of Care document
- Nov 2016
  - Submission of document for BOD approval

Updated 2017

# Lab Values Interpretation Resource

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Academy of Acute Care Physical Therapy – APTA
Task Force on Lab Values

**2017 Members**
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Traci Norris, PT, DPT, GCS | Co-Chair
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Kathy Swanick, PT, DPT, OCS
Julie Terrell, PT
Risa Maruyama, PT, NCS

## 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!!!

## Lab Value Considerations

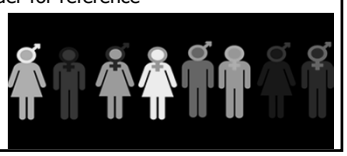
Age Considerations

- "Norms" are created for healthy adults
- Considerations for mobility based on age and current medical condition
- Did not include lab ranges for the pediatric population

## Lab Value Considerations
Sex and Gender Considerations

Considerations for:

- Patient's biological sex, gender, and gender identity
  - Avoid referencing the incorrect "normal" value
- HRT (reference value)
  - Use the transitioned gender for reference
- No HRT – biological sex



## 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, $SpO_2$, EKG
    - HR <60 or >120
    - SBP <90 or <180
    - $SpO_2$ < 90%
    - Dysrhythmia
- Patient symptomology
  - New onset or worsens
  - Trend

Collaboration with the health care team

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# Movement System

## The Human Movement System

APTA American Physical Therapy Association

Our Vision-

Transforming society by optimizing movement to improve the human experience

IDENTITY

FOUNDATION

The Core Of Physical Therapist
Practice, Education, and Research

American Physical Therapy Association (2015)

## Human Movement System

American Physical Therapy Association (2015)

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

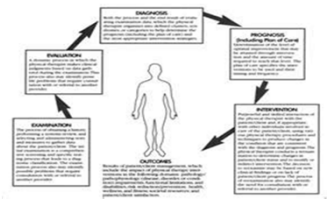
**Human movement is a complex behavior within a specific context.**

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.

American Physical Therapy Association (2015).

## 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.

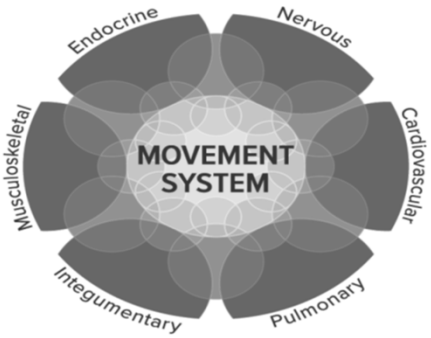



American Physical Therapy Association (2015).

## Physical Therapist Practice and the Human Movement System

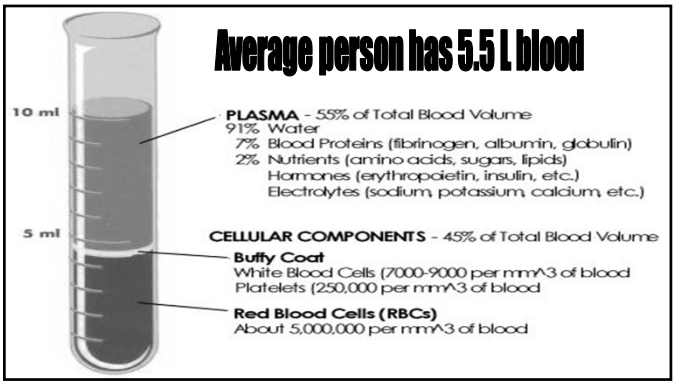
Physical therapists maximize an individual's ability to engage with and respond to his or her environment using movement-related interventions to optimize functional capacity and performance.

American Physical Therapy Association (2015).




## 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



## 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 $mm^3$

1 L = 1000 mL = 0.001 $m^3$ = .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*

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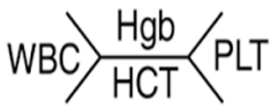
## Complete Blood Count (CBC)



## Complete Blood Count

Routine Test of Blood (RBC, WBC, Plt)

Screens for:

- Anemia
- Infection
- Coagulation disorders

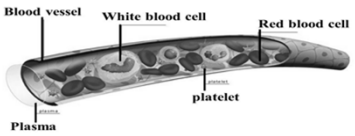
Different levels of "complete" blood detail

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

| | WBC ($10^9$/L) Leukocytes | Hematocrit % | Hemoglobin (g/dL) | PLT (ku/L) Thrombocytes |
|---|---|---|---|---|
| **Adult Male** | 5.0-10 | 42-52 | 14.0-17.4 | 140-400 |
| **Adult Female** | 5.0-10 | 37-47 | 12-16 | 140-400 |

## 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
  - http://i.imgur.com/YOftVYv.mp4
- 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 1° bone marrow disorders
  - Chemotherapy and/or radiation treatments
  - 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)
  - $SpO_2$ to predict tissue perfusion
    - Clinical significant (desaturation)
      - $SpO_2$ < 88% during exercise
      - $SpO_2$ 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 heath care tea

## 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*

Scott BH, Seifert FC, Grimson R. Blood transfusion is associated with increased resource utilisation, morbidity and mortality in cardiac surgery. Ann Card Anaesth 2008;11:15-9
Shander AS, Goodnough LT; *Blood Transfusion as a Quality Indicator in Cardiac Surgery JAMA.* 2010;304(14):1610-1611.
Hajjar L; *TRACS: Differing blood transfusion strategies yield similar complication, death rates in cardiac surgery patients* JAMA. 2010;304;1559-1567

## 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

Carson, J. L., Guyatt, G., Heddle, N. M., Grossman, B. J., Cohn, C. S., Fung, M. K., ... & Peterson, N. (2016). Clinical practice guidelines from the AABB: red blood cell transfusion thresholds and storage. *JAMA, 316*(19), 2025-2035.

## 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

Rosenfeldt, A. B., Pilkey, L. M., & Butler, R. S. (2016). A Survey of Physical Therapists Attitudes and Practice Patterns Regarding Intervention During a Red Blood Cell Transfusion. *The Journal of Acute Care Physical Therapy.*

## Polycythemia (Erythrocytosis)

Primary
- Disease of the bone marrow – Unknown etiology

Secondary (compensatory)
- Physiological manifestation
- Due to decreased $O_2$ 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

## Platelets (thrombocytes)

**Reference Value 140-400 k/uL**

Responsible for initiation of clotting

Thrombocytosis (trending up)
- < 450 k/uL

Thrombocytopenia (trending down)
- < 150 k/uL

## 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)

| Hct | Hgb | WBC |
|---|---|---|
| < 25%<br>Light ROM and isometrics<br>Avoid aerobic or progressive programs<br><br>25-35%<br>Essential ADL's<br>Assistance for safety<br>light aerobics or weights<br><br>> 35%<br>Mobilize and self care as tolerated<br>Resistance exercises | < 8.0 gm/dL<br>Light ROM and isometrics<br>Avoid aerobic or progressive programs<br><br>8.0-10 gm/dL<br>Essential ADLs<br>Assistance for safety<br>Light aerobics or weights<br><br>> 10.0 gm/dL<br>Ambulation and self care as tolerated, resistance ex | < 5.0 $10^9$/L (w/fever)<br>No exercise permitted<br><br>> 5.0 $10^9$/L<br>Light exercise progress to resistive exercise permitted |

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

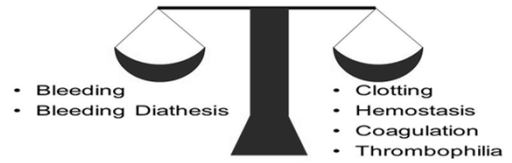
| Hct | Hgb | WBC |
|---|---|---|
| < 15-20% (critically low value)<br>• Cardiac failure or death<br><br>< 25%<br>• Symptoms based approach<br><br>> 60% (critically high value)<br>• Spontaneous blood clotting | < 5-7 g/dL (critically low value)<br>• Can lead to heart failure or death<br><br>< 8 g/dL<br>• Symptoms-based approach<br><br>> 20 g/dL (critically high value)<br>• Can lead to clogging of capillaries as a result of hemoconcentration | > 11.0 $10^9$/L Leukocytosis<br>• Symptoms based approach<br><br>< 4.0 $10^9$/L Leukopenia<br>• Symptoms based approach<br>• Especially in the presence of fever<br><br>< 1.5 $10^9$/L Neutropenia<br>• Symptoms based approach<br><br>• Facility based neutropenic procedures |

ACADEMY OF ACUTE CARE PHYSICAL THERAPY

# Blood Viscosity

## Bleeding and Clotting Disorders

The Precarious Balance




***the anticoagulants vs. the procoagulants***

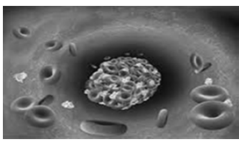
## Physics of Blood Viscosity

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

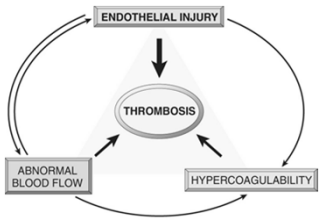
## Hemostasis

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



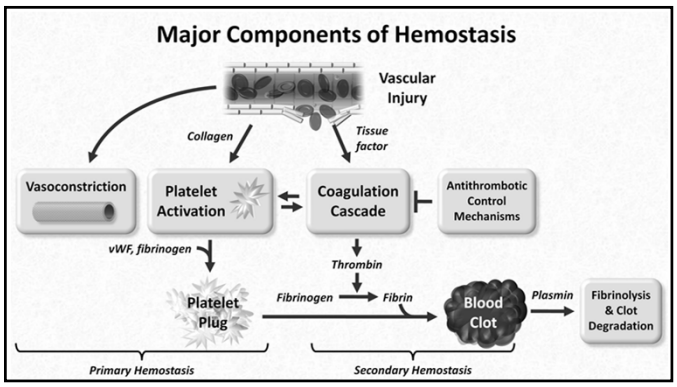
## Basics of Clotting

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



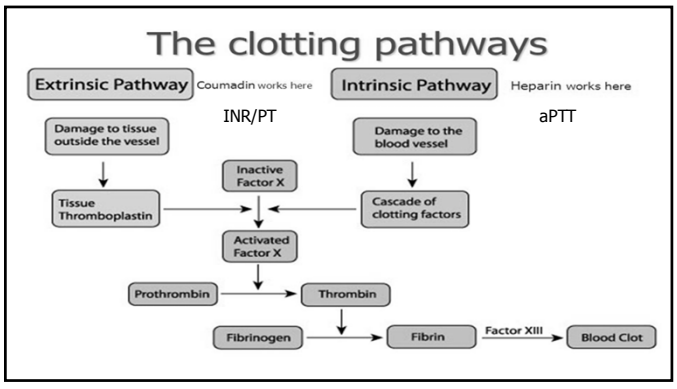

## Basics of Clotting

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

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



## Excessive Bleeding Disorders

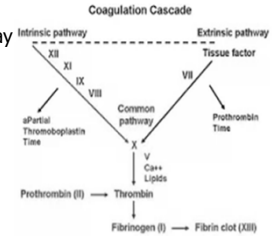
Hemophilia A = Factor VIII deficiency
- Abnormal PTT and factor VIII assay

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

| Thrombophilia | Acquired | Inherited |
|---|---|---|
| Antithrombin deficiency | X | X |
| Factor V Leiden | | X |
| Prothrombin gene mutation | | X |
| Protein C deficiency | X | X |
| Protein S deficiency | X | X |
| Elevated levels of factor VIII* | X | X |
| Elevated levels of factor IX, XI* | | X |
| Antiphospholipid antibody syndrome (APS) | X | |

## Hemostasis

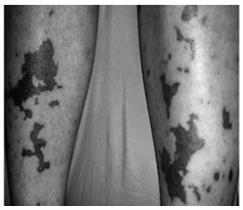
- DNA testing to determine inherited defect
- Antiphospholipid antibodies
- Antithrombin deficiency and protein C deficiency
- Protein S deficiency
- Fibrinogen Assay
  - Quantitates fibrinogen
  - Normal = 200 - 400 mg/dL
- Factor Assays
  - Quantitates all coagulation factors
  - Normal = 50 - 150%

## Clotting Disorders - Disseminated Intravascular Coagulation

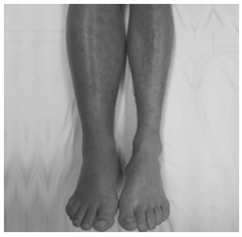
Excessive clotting

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

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

Does This Patient Have Deep Vein Thrombosis? Wells P, Owen C, Doucette S, Fergusson D, Tran H JAMA 2006; 295(2): 199-207

## 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

| Clinical Feature | Score |
|---|---|
| Clinically suspected DVT | 3.0 |
| No alternative diagnosis better explains the illness | 3.0 |
| Tachycardia | 1.5 |
| Immobilization (>3 d)/ surgery in previous four weeks | 1.5 |
| History of DVT or PE | 1.5 |
| Hemoptysis | 1.0 |
| Malignancy (with treatment within 6 months) or palliative | 1.0 |

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

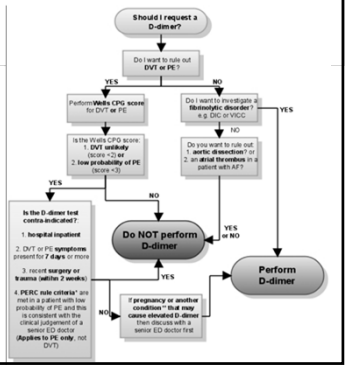
## D-Dimer

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

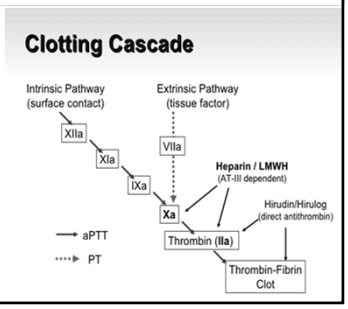
Imaging

- 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
- ↑INR ~ ↑risk of bleeding
- Extrinsic coagulation pathway

INR (International Normalized Ratio) = $(\text{Patient PT}/\text{Normal PT})^{ISI}$*

## International Normalized Ratio (INR)

| International Normalized Ratio (INR) | |
|---|---|
| **Normal range** | 0.8-1.2 |
| **Therapeutic Range (VTE, PE, patients with atrial fibrillation)** | 2.0 to 3.0 |
| **Therapeutic range for patients at higher risk (prosthetic heart valves)** | 2.5-3.5 |
| **Therapeutic range for patients with lupus anticoagulant** | 3.0-3.5 |
| **Therapeutic range for stroke prophylaxis** | 2.0-2.5 |
| **Patient at higher risk for bleeding** | > 3.6 |

Holbrook A, et al. (2012). Evidence-Based Management of Anticoagulant Therapy: Antithrombotic Therapy and Prevention of Thrombosis 9th Edition: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. Chest, 141:e152S-184S.

## 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

ACADEMY OF ACUTE CARE PHYSICAL THERAPY

## 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

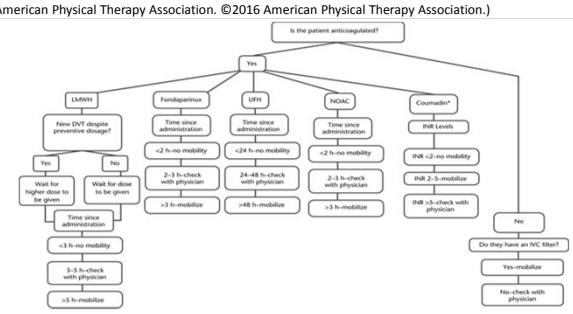
## Anticoagulation Medications

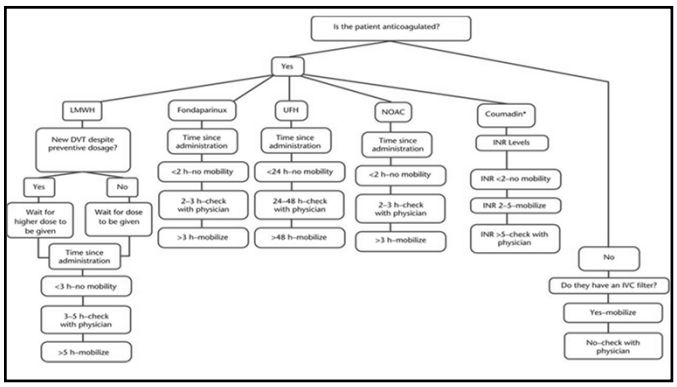
Oral Medications
- Aspirin
- Clopidogrel (Plavix)
- Fondaparinux (Arixtra)
- Warfarin (Coumadin)
- Dabigatran (Pradaxa)
- Rivaroxaban (Xarelto)
- Apixaban (Eliquis)
- Savaysa (Edoxaban)

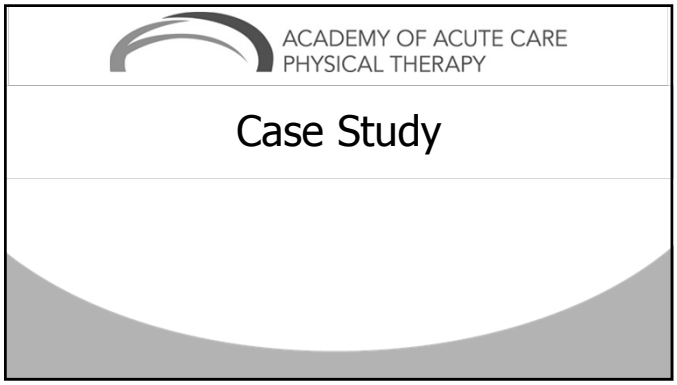
Intravenous
- Heparin
  - Bridging
  - Short acting

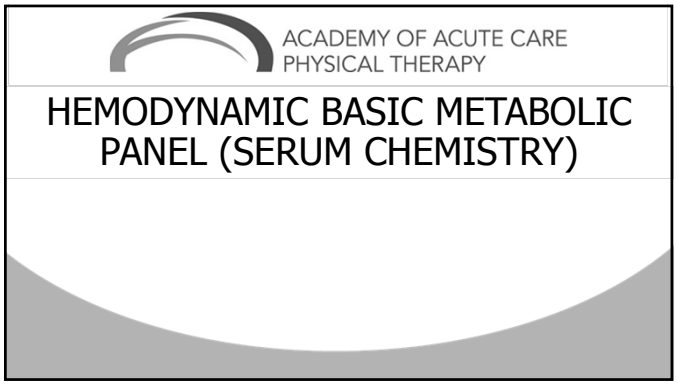
Subcutaneous
- Heparin
- Low molecular weight heparin (LMWH) (Lovenox)

**Algorithm for Mobilizing Patients with Known Lower-Extremity Deep Vein Thrombosis** (Reprinted from *Phys Ther*. 2016;96:143-166,with permission of the American Physical Therapy Association. ©2016 American Physical Therapy Association.)





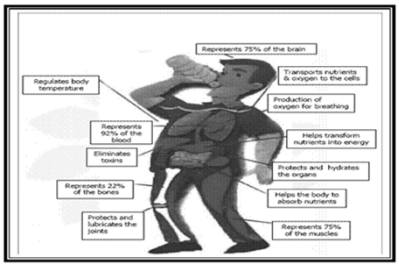



## Labs

**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

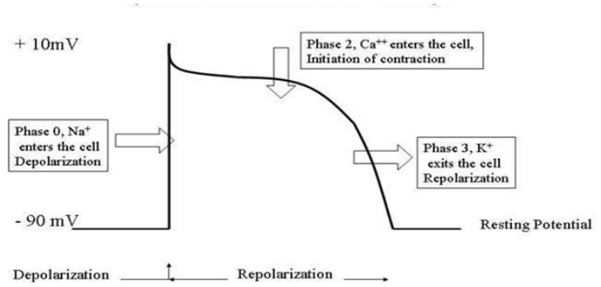
**Causes**

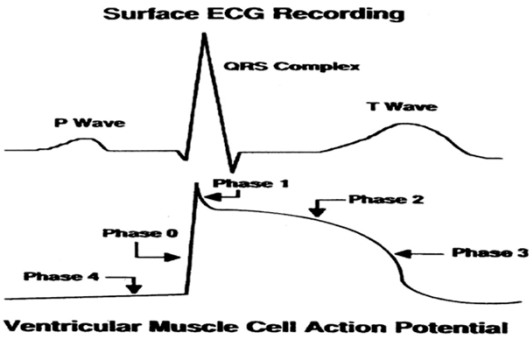
- Limited oral intake
  - CVA
  - AMS
- Excess loss
  - Vomiting/diarrhea
  - DM
  - Burns
  - Excessive Sweating

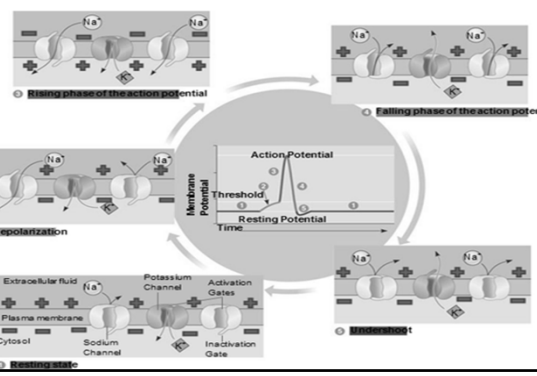
**Presentation**

- Dry Mucus Membranes
- Poor skin turgor
- Hypotension (orthostatic)
- Tachycardia
- Tachypnea
- AMS

## Sodium



## Sodium
## Hypernatremia Na+> 150 mEq/L

**Causes**
- Hypovolemia
- Increased Na intake
- Severe vomiting
- CHF
- Renal f/ins
- Cushing's syndrome
- Diabetes

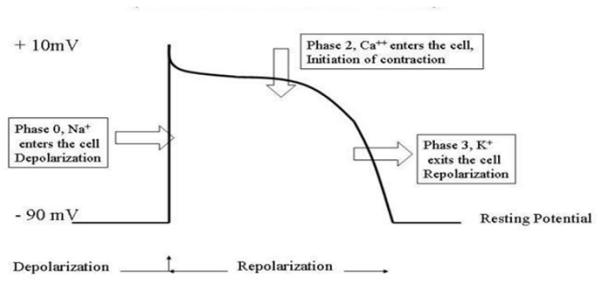
**Presents**
- Irritability
- Agitation
- Seizure
- Coma
- Hypotension
- Tachycardia
- Weak pulse
- Decreased urine output

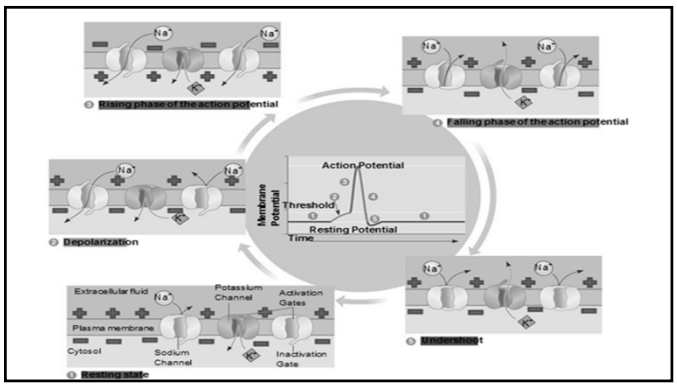
## Sodium
## Hyponatremia Na+ < 135 mEq/L

**Causes**
- Diuretic use
- GI loss
- Burns/wounds
- Hypotonic IV use
- Cirrhosis

**Presents**
- Headache
- Lethargy
- Decreased reflexes
- Nausea vomiting
- Diarrhea
- Seizure
- Coma
- Orthostatic hypotension
- Pitting edema

## Potassium






## Potassium
## Hyperkalemia K+ > 5.3 mEq/L

**Causes**
- Renal failure
- Metabolic acidosis
- DKA
- Addison's disease
- Excesses K supplements
- Blood transfusions

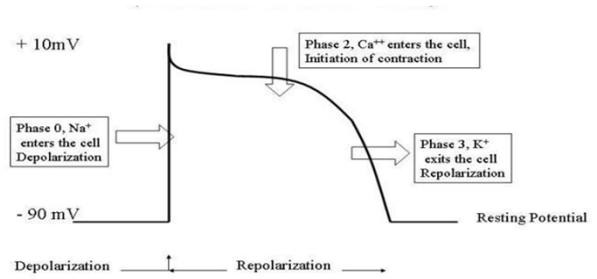
**Presents**
- Muscle weakness/paralysis
- Paresthesia
- Bradycardia
- Heart Block
- V-fib
- Cardiac arrest

## Potassium
## Hypokalemia K+ < 3.0 mEq/L

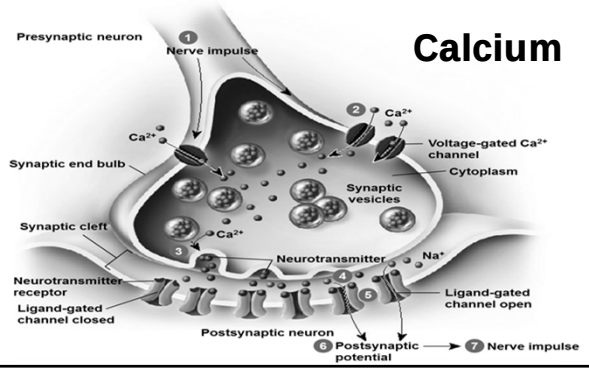
**Causes**
- Diarrhea/vomiting
- GI losses/NG suction
- Diuretics
- Cushing Syndrome
- Malnutrition
- Restrictive diets
- ETOH abuse

**Presents**
- Extremity weakness
- Hyporeflexia
- Paresthesia
- Leg Cramps
- ECG changes
- ST depression
- Inverted Ts
- Cardiac arrest
- Hypotension
- Constipation

## Calcium




## Calcium




## Calcium
## 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

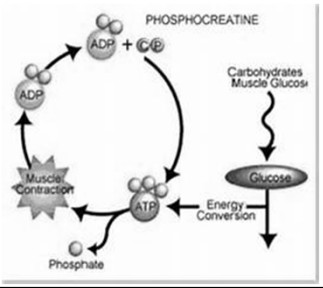
**Causes**
- ETOH abuse
- Poor dietary intake
- Limited GI absorption
- Pancreatitis
- Laxative use

**Presents**
- Anxiety
- Confusion
- Agitation
- Seizure
- Prolonged QT interval
- Fatigue
- Numbness/tingling
- Hyperreflexia
- Muscle cramps

## Phosphate

Hypophosphatemia <2.4 mg/dL
- same as hypocalcemia

Hyperphosphatemia >4.8 mg/dL
- Same as hypercalcemia




## Chloride
## Hyperchloremia > 110 mEq/L

**Cause**
- High salt low water diet
- Hypertonic IV
- Metabolic Acidosis
- Renal Failure

**Presents**
- Lethargy
- Decreases level of consciousness
- Weakness
- Edema
- Tachypnea
- HTN
- Tachycardia

## Chloride
## Hypochloremia < 104 mEq/L

**Causes**
- Low salt diet
- Water intoxication
- Diuresis
- Excessive vomiting/diarrhea

**Presents**
- Agitation
- Irritability
- Hypertonicity
- Hyperreflexia
- Cramping
- Twitching

## Magnesium
## Hypermagnesemia > 2.7mEq/L

**Causes**
- Increased intake
  - Antacids
  - Mag-citrate
- Renal failure
- Leukemia
- Dehydration

**Presents**
- Diaphoresis
- Nausea/vomiting
- Drowsiness
- Lethargy
- Weakness/flaccidity
- Decreased DTR
- Hypotension
- Heart block

## Magnesium
## Hypomagnesemia < 1.8 mEq/L

**Causes**
- ETOH
- Eating disorders
- Diuresis
- DKA
- Medications

**Presents**
- Hyperreflexia
- Tremors
- Spasticity
- Seizures
- Nystagmus
- Prolonged PR/QT intervals
- PVC, VT, VF
- Emotional lability

## 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

ACADEMY OF ACUTE CARE PHYSICAL THERAPY

## 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.

| BNP | NYHA Class |
|---|---|
| < 100 pg/mL | No risk of heart failure |
| 100–300 pg/mL | Class I – Cardiac disease, but no symptoms and no limitation in ordinary physical activity, e.g. no shortness of breath when walking, climbing stairs etc.. |
| > 300 pg/mL | Class II – Mild symptoms (mild shortness of breath and/or angina) and slight limitation during ordinary activity. |
| > 600 pg/mL | 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. |
| > 900 pg/mL | Class IV – Severe limitations. Experiences symptoms even while at rest. |

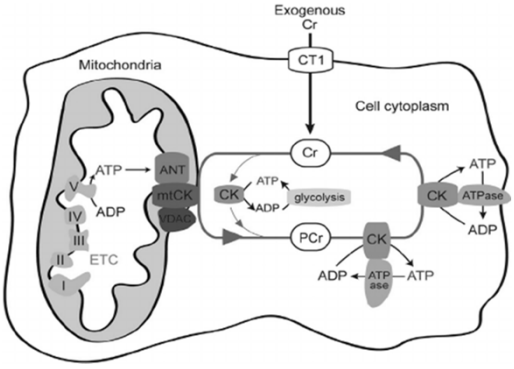
- Maisel AS, Krishnaswamy P, Nowak RM, et al. Rapid measurement of B-type natriuretic peptide in the emergency diagnosis of heart failure. *N Engl J Med.* 2002;347:161-167.
- Palazzuoli A, Gallotta M, Quatrini I, Nuti R. Natriuretic peptides (BNP and NT-proBNP): measurement and relevance in heart failure. Vasc *Health Risk Manag.* 2010;6:411-418.

## Creatinine Kinase (CK) Normal = 30-170 IU/L

Cytoplasmic Enzyme of Muscle- 3 forms

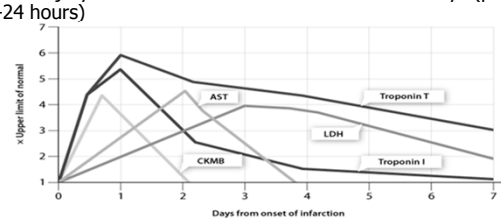
CK initiates the conversion of creatinine and utilizes adenosine triphosphate (ATP) to create phosphocreatine (PCr) and adenosine diphosphate (ADP).

- 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)



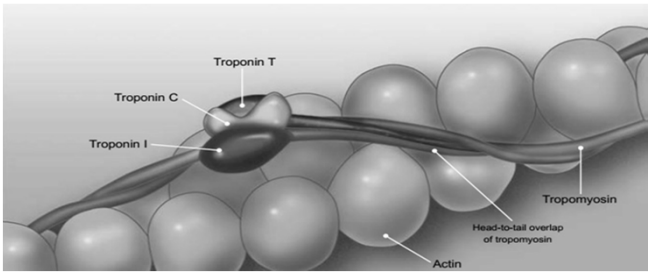

## Troponin

Troponin I binds to actin in thin myofilaments to hold the troponin-tropomyosin complex in place

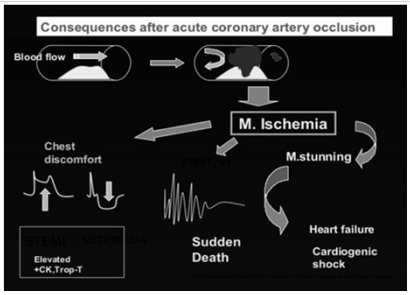
Troponin T binds to tropomyosin, interlocking them to form a troponin-tropomyosin complex

(N < 0.03 ng/mL)

## Troponin



## Cardiac Specific Testing



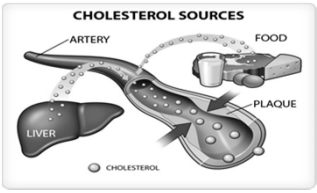

## Lipid Profile

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

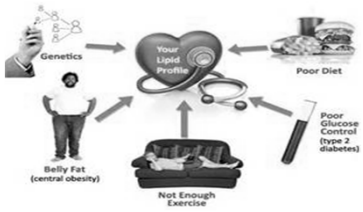
Genetics
Smoking
Diet
Medications- oral contraceptives, sulfonamides, aspirin, steroids
Hypothyroid
Exercise
ETOH



## HDL/LDL


## Triglycerides

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




## Lipid Profile

| | | |
|---|---|---|
| **LDL** | <70 | Target if high risk for heart disease |
| | <100 | Target for heart disease or diabetes |
| | <130 | Target for 2 or more risk factors |
| | <160 | Target for 1 or 0 risk factors |
| | 160-189 | High |
| | >189 | Very High |
| **HDL** | <40 | Target |
| | >60 | The higher the better |
| **Total Cholesterol** | <200 | Target |
| | 200-239 | Borderline High |
| | >240 | High Risk |
| **Triglycerides** | <150 | Target |
| | 150-199 | Moderate Risk |
| | 200-499 | High Risk |
| | >499 | Very High Risk |
| | >1000 | At risk for pancreatitis |

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

## Other Cardiac Markers
## 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

**Hs-CRP**

| | |
|---|---|
| <1 | Low Risk |
| 1-3 | Average Risk |
| >3 | High Risk |

ACADEMY OF ACUTE CARE PHYSICAL THERAPY

## Arterial Blood Gas

## Acid Base Balance

Respiratory Acidosis
Respiratory Alkalosis
Metabolic Acidosis
Metabolic Alkalosis

The ratio of $HCO_3/PaCO_2$ effects pH
Normal Blood pH 7.35-7.45

## Acid Base Balance

Respiratory Acidosis

Condition caused by hypoventilation of the alveoli leading to increased arterial carbon dioxide ($PaCO_2$)
Blood pH< 7.35

## Acid Base Balance

Respiratory Acidosis

Hypercapnia
Hypoventilation
Headache
Visual Disturbances
Confusion
Drowsiness
Depressed Tendon Reflexes
Hyperkalemia
Ventricular Fibrillation- caused by hyperkalemia

## Acid Base Balance

Respiratory Alkalosis

Condition caused by hyperventilation of the alveoli leading to decreased plasma carbon dioxide concentration (pCO2)
Blood pH> 7.45

## Acid Base Balance

Respiratory Alkalosis

- Hypocapnia
- Lightheadedness
- Numbness/tingling of digits
- Hypocalcaemia
- Hypokalemia
- Cardiac Dysrhythmias secondary Hypokalemia

## Acid Base Balance

Metabolic Acidosis

- Bicarbonate deficit
- Hyperventilation
- Headache
- Hyperkalemia
- Stupor

## 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 ($HCO_3^-$)
- Reference Value- 8 to 10 mEq

The anion gap (AG) it 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

**pCO2**

The amount of carbon dioxide dissolved in arterial blood.

The normal range is 35 to 45 mm Hg.

pCO2 >45 = acidosis
pCO2 <35 = alkalosis

## Components of the Arterial Blood Gas

**HCO3**

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

The normal range is 22 to 26 mEq/liter

HCO3 > 26 = alkalosis
HCO3 < 22 = acidosis

## Components of the Arterial Blood Gas

**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.

C

TABLE 1

| Normal ABG Figures | |
|---|---|
| PH | 7.35-7.45 |
| PO2 | 80-100 |
| PC02 | 35-45 |
| HC03 | 22-28 |

## 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".

| | | |
|---|---|---|
| pH | 7.50 | (7.35-7.45) |
| pCO2 | 42 | (35-45) |
| HCO3 | 33 | (22-26) |

## Step One

| | | | |
|---|---|---|---|
| pH | 7.50 | (7.35-7.45) | ALKALINE |
| pCO2 | 42 | (35-45) | NORMAL |
| HCO3 | 33 | (22-26) | ALKALINE |

## Step Two

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

| | | | |
|---|---|---|---|
| pH | 7.50 | (7.35-7.45) | ALKALINE |
| pCO2 | 42 | (35-45) | NORMAL |
| HCO3 | 33 | (22-26) | ALKALINE |

## Step Two

| | | | |
|---|---|---|---|
| pH | 7.50 | (7.35-7.45) | ALKALINE |
| PaCO2 | 42 | (35-45) | NORMAL = Lungs |
| HCO3 | 33 | (22-26) | ALKALINE = Kidneys |

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".

| | | |
|---|---|---|
| pH | 7.31 | (7.35-7.45) |
| PaCO2 | 39 | (35-45) |
| HCO3 | 17 | (22-26) |

## Step One

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

| | | | |
|---|---|---|---|
| pH | 7.31 | (7.35-7.45) | Acidosis |
| PaCO2 | 39 | (35-45) | Normal |
| HCO3 | 17 | (22-26) | Acidosis |

## Step Two

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

| | | | |
|---|---|---|---|
| pH | 7.31 | (7.35-7.45) | Acidosis |
| PaCO2 | 39 | (35-45) | Normal |
| HCO3 | 17 | (22-26) | Acidosis |

## 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

A patient can be uncompensated, partially compensated, or fully compensated

## Compensation

| | | | |
|---|---|---|---|
| pH | 7.38 | (7.35-7.45) | NORMAL |
| PaCO2 | 56 | (35-45) | ACIDOSIS |
| HCO3 | 35 | (22-26) | ALKALOSIS |

## Compensation

- 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.

## Compensation

| | | | |
|---|---|---|---|
| pH | 7.38 | (7.4) | ACIDOSIS |
| PaCO2 | 56 | (35-45) | ACIDOSIS |
| HCO3 | 35 | (22-26) | ALKALOSIS |

## Compensation

| | | | |
|---|---|---|---|
| pH | 7.38 | (7.4) | ACIDOSIS |
| PaCO2 | 56 | (35-45) | ACIDOSIS = Lungs |
| HCO3 | 35 | (22-26) | ALKALOSIS |

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!

## Compensation

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.***

| | | | |
|---|---|---|---|
| pH | 7.38 | (7.4) | ACIDOSIS |
| PaCO2 | 56 | (35-45) | ACIDOSIS = Lungs |
| HCO3 | 35 | (22-26) | ALKALOSIS |


## Special and Disease Specific Tests

## Carbohydrate Metabolism Tests

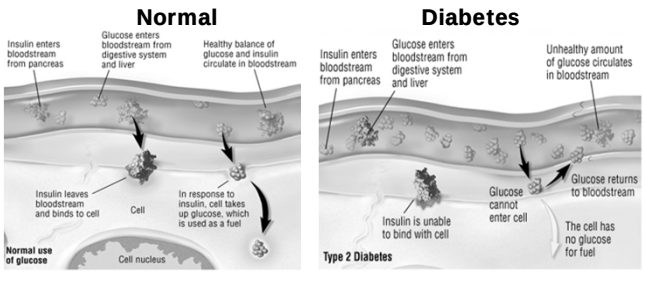
- Glucose
- Hgb A1C (Glycosylated hemoglobin)


## 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



## Glucose- Hyperglycemia (> 200 mg/dL)

**Causes**

- Diabetes mellitus
- Sepsis
- Brain Tumors
- Certain medications
- High dose steroids
- IV glucose
- After a meal*
- Cushing's disease*
- Pancreatitis

**Presentation**

- DKA
- Severe Fatigue

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

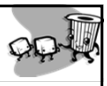
**Causes**

- Excess insulin
- Brain injury
- Pituitary deficiency (hypothyroidism)
- Malignancy
- Addison's disease
- Presence of benign insulin-producing tumor*
- Starvation*

**Presentation**

- Headache*
- Fatigue*
- Lethargy*
- Hunger*
- Tachycardia*
- Irritability
- Shaking/tremor*
- Extremity Weakness
- Sweating*
- Anxiety/Confusion*
- Loss of consciousness

## Implications of Altered Glucose



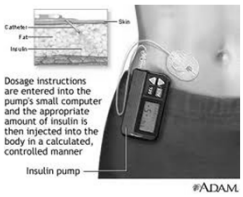
- Decreased tolerance to activity
- May not tolerate therapy until glucose level increased
- A glucose target between 140-180 mg/dL is recommended for most patients in noncritical care units while hospitalized
- Check for most recent glucose levels (before/after exercise if outpatient)
- If levels are 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% )

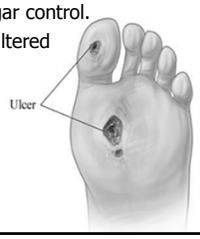
Normal: < 5.7%
- Pre-diabetes mellitus: 5.7 - 6.4%
- With diabetes mellitus: > 6.5% (poor glucose control)

## Hgb A1C

| **Causes** | **Presentation** |
|---|---|
| Diabetes mellitus | Eye disease<br>Heart disease<br>Kidney disease<br>Nerve damage<br>Stroke<br>Gum disease<br>Non-traumatic amputations |

## Implications of Altered Hgb A1C

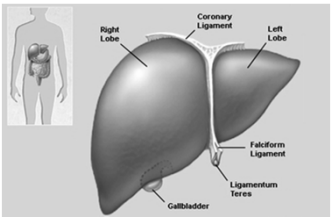
- Monitor vitals as a standard of care
- Educate importance of exercise for blood sugar control.
- Consider wound-care management if levels altered



## Patient Case

## Importance of Hepatic Function

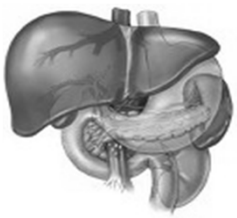
- Protein synthesis
- Storage
- Nutrient metabolism
- Blood Glucose regulation
- Bile drainage
- Blood circulation and filtration
- Detoxification




## Hepatic Function Tests

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

- Serum Albumin
- Serum Pre-Albumin
- Ammonia ($NH_3$)
- Serum Bilirubin
- Liver Enzymes

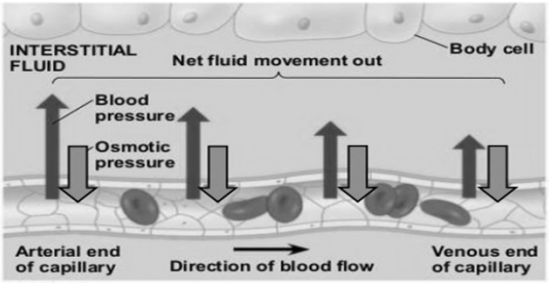


## Serum Albumin and Serum Prealbumin

**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

| Prealbumin Level | Protein Depletion |
|---|---|
| 0-5 mg/dL | Severe |
| 5-10 mg/dL | Moderate |
| 10-15 mg/dL | Mild |

## Serum Albumin and Pre-albumin Trending Upward

**Causes**

Nutritional compromise
Severe infections
Congenital disorders
Severe dehydration
Hepatitis
Chronic inflammation
Tuberculosis
Overdose of cortisone medications
CHF
Renal Disease
Cancer

**Presentation**

Clinical features are dependent on the cause
- i.e. renal, cardiac, TB, etc.
- Systemic peripheral edema
- Delayed wound healing

## Serum Albumin and Pre-albumin Trending Downward

**Causes**

Infection
Inflammation
Liver disease
Kidney disease
Crohn's disease
Burns
Malnutrition/malabsorption
Thyroid disease

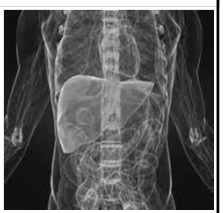
**Presentation**

Peripheral edema
Non-healing wound
Hypotension


## Hypoalbuminemia

**Albumin levels**
- < 3.0 g/dL nutritionally compromised
- < 2.8 g/dL peripheral edema, poor wound healing

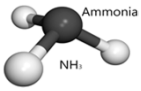
**Serum Prealbumin:** 19-39 mg/dL
- < 10 g/dL significant nutritional risk



**Clinical Implications**
- Assess integumentary (incisions) daily
- Collaborate with the interdisciplinary team regarding nutrition

## Ammonia ($NH_3$) 15-60 µg/dL

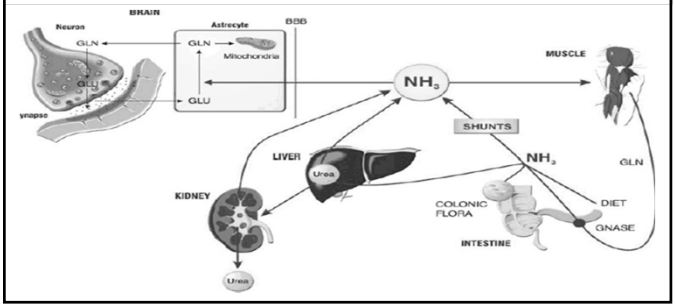
**Ammonia:**




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

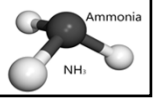
**Causes**
- Cirrhosis
- Severe hepatitis
- Reye's syndrome
- Severe heart disease
- Kidney failure
- Severe bleeding of stomach or intestines (GI Problems)

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

## Ammonia ($NH_3$) 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.

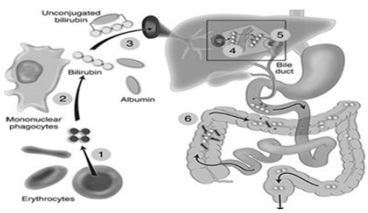



## Serum Bilirubin 0.3-1.0 mg/dL

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

MELD Score

- Serum bilirubin
- Serum creatinine
- INR

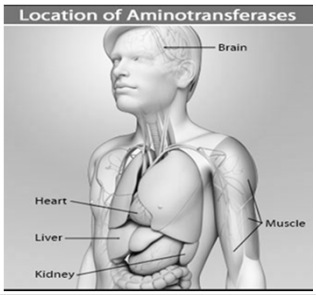
MELD-Na

- Serum bilirubin
- Serum creatinine
- INR
- Sodium

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

MELD Score and 3 Month Mortality
- 40 or more — 71.3% mortality
- 30–39 — 52.6% mortality
- 20–29 — 19.6% mortality
- 10–19 — 6.0% mortality
- < 9 — 1.9% mortality

## Liver Enzymes




## 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, cirrohosis or hepatoxic drugs

## Clinical Bottom Line

Red Flags for liver dysfunction include:

- Altered cognition or mental status
- Ascities
- 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.

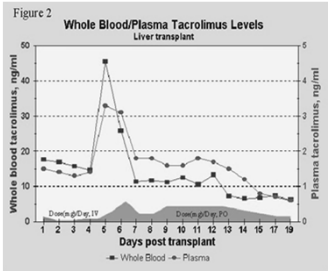
## Patient Case

## 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

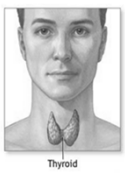
## Thyroid Function Tests

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)

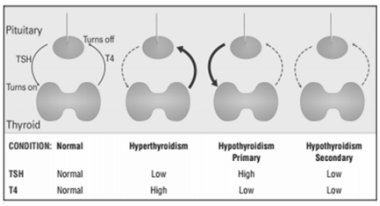


## Thyroid Function Tests Reference Ranges

- 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)
  - 0.3-3.0mlU/L
- Increased TSH and decreased T4 = thyroid disease
- Decreased TSH= pituitary disease

## Thyroid Function Tests

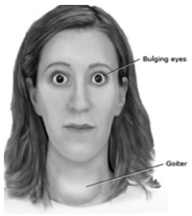
Increased TSH and decreased T4 = thyroid disease
Decreased TSH= pituitary disease




| CONDITION: | Normal | Hyperthyroidism | Hypothyroidism Primary | Hypothyroidism Secondary |
|---|---|---|---|---|
| TSH | Normal | Low | High | Low |
| T4 | Normal | High | Low | Low |

## 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 periarthritis
- 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.

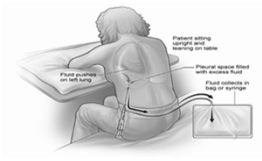
## Thoracentesis

What is it?

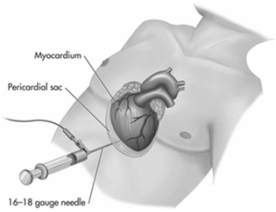
A procedure to remove excess fluid in the space between the lungs and chest wall (aka the pleural space).

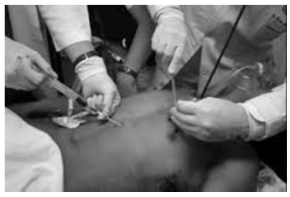
Pathology causing fluid accumulation (aka pleural effusion):

- tumors
- pneumonia
- thyroid disease
- chronic lung diseases
- congestive heart failure
- pulmonary embolism



## PERICARDIOCENTESIS



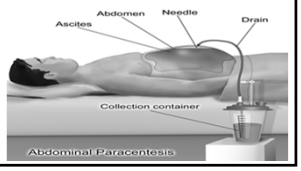
## Paracentesis

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



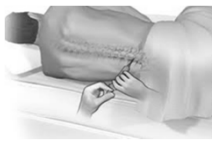

## Lumbar Puncture

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)



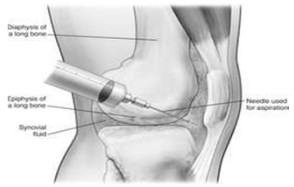
## Arthrocentesis

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

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## Case Studies

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