



## Interpretation of Clinical Laboratory Tests

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### Learning Objectives

- **Discuss the importance of**
  - When to draw labs
  - What a "Normal Lab Value" means
  - What an "Abnormal Lab Value" means
  - Potential for error in
    - Laboratory test values
    - Units of measure
    - Timing
    - Technique in drawing
- **Discuss the differences in chemistry profiles**
  - BMP (SMA-6, Basic Metabolic Profile)
  - Chem Panel-12 (SMA-12)
  - CMP (Complete Metabolic Profile, Chem Profile-20)
  - Renal Panel
  - Critical Care Panel
  - Cost/benefit issues.
- **List 3 class of drugs that require periodic drug level monitoring**
  - To minimize adverse reactions
  - To maximize effectiveness.
- **List one frequently monitored test value for**
  - Asthma
  - Congestive heart failure
  - Diabetes
  - Cancer.

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### What is a Blood test?

- An essential diagnostic tool that reveals details about:
  - Blood cells
  - Blood components
  - Fluids and Electrolytes
  - Electrolytes
  - Nutritional status
  - Body organ function
  - Acid-base status
  - Immune function
  - Compliance with medication regimens

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## Blood Components

### Plasma (semi-solid component)

- Plasma Albumin, immunoglobulin, coagulation factors, protein C and S, fibrinogen, antithrombin, platelets, etc.
- Turns into a solid when clotting cascade activated

### Serum (liquid component)

- Dissolved components, drugs, electrolytes, gases, etc.
- Serum, The remaining liquid, which can be used in blood tests to assist in determining how various body organs may be functioning

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## When should we actually draw a blood test?

### Suspicion leads the clinician to believe there is a medical problem

- Infectious diseases (CBC/Differential; Legionella titers, Tularemia, etc.)
- VTE / Pulmonary embolism (D-Dimer)
- Adrenal Insufficiency (Serum Cortisol pre and post Cosyntropin Injection)
- Hypo / Hyperthyroidism (Cardiac Arrhythmias, Fatigue, F.U.O., etc.)
- Systemic Lupus Erythematosus
- Inflammatory Conditions (CRP, ESR)
- And ON....and ON....and ON.
- BASICALLY To ASSIST in confirmation of diagnosis

### To follow up on prescribed therapy

- Serum Drug Levels (gentamicin, vancomycin, digoxin, theophylline, thiocyanate)
- Hemoglobin A1-C (HgA1C)
- Prostate Specific Antigen (PSA)
- Culture and Sensitivities (C&S)
- Carcinoembryonic Antigen (CEA)

### Should NOT draw lab test if nothing is going to be acted upon

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## Common conditions for acquiring blood lab tests

- Allergies
- Autoimmune Diseases
- Blood Cholesterol
- Diabetes
- DNA, Paternity and Genetic Testing
- Drug Screening
- Environmental Toxin
- Nutritional status
- Gastrointestinal Diseases
- Heart Health
- Hormones and Metabolism
- Infectious Disease
- Kidney Disease
- Liver Diseases
- Sexually Transmitted Diseases
- Thyroid Disease

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## Overview

- Specialized lab tests
- Specific disease states
- Specific drug therapy
- Implications for case management

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## General Principles

- Serum, blood, urine, CSF other fluids
  - Screening
    - Qualitative
    - Urine drug screens
    - Example (urine drug screen obtunded teenage girl → opiates)
  - Diagnostic
    - Quantitative
    - Serum drug levels
    - Example (serum Fentanyl Level 5 mcg/ml in same teenage girl, 2 days post presentation to ICU with no narcotics given in past 2 days → DATE RAPED with fentanyl disk)
- Cost vs benefit
  - Benefit must outweigh the cost or danger of procedure
    - Every blood stick introduces chance for infection
    - Daily blood sticks or multiple blood draws throughout therapy may lead to anemia such as seen in the ICU or in the chronic dialysis patient (multiple blood draws do contribute to some of the anemia in dialysis patients due to their lack of erythropoietin in regenerating substrate)
  - Outcome must affect decisions in therapeutic management
    - BNP greater than 400 in acutely decompensated CHF patient → NATRECOR treatment (expensive drug, but will keep patient out of ICU)

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## General Principles: Normal Values

- "Normal Range"
  - Defined by healthy population
  - Vary widely within age groups, weight groups, sex, feeding status
  - THUS, normal is only normal in the bell curve of a population
  - REMEMBER...there is NOT NORMAL serum drug level...only therapeutic, subtherapeutic and toxic ranges.
  - Pediatric values are different than adult values
- Variations do exist
  - Age, Sex, wt, ht, food, drug-effect, diseases, etc.
    - Serum creatinine is a fantastic example of how one can MISINTERPRET renal function in the elderly
    - Renal Dysfunction, pregnancy and neonate are fantastic examples of how one can MISINTERPRET serum digoxin levels
    - Personal Norms
- Variations among labs
  - Use norms listed by lab, keep in mind that there are three blood test "normal ranges."
- Personal Norms
  - Just like temperature, all have individual normals
  - High normal may be extreme high in some patients (example: WBC 10,000 may be normal in most, but someone who normally runs 4,000, this could be signs of serious infection)
- Be sure to review the individual labs reference points for normal ranges when assessing

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## Lab Error

- **Specimen problem**
  - hemolyzed blood
    - Hyperkalemia, hyperphosphatemia.
  - Lipemic Serum
    - Pseudo-hyponatremia
  - CPK enzymes in patient lying on floor too long
- **Wrong time**
  - Vancomycin / Gentamicin Peak / Trough
    - Frequently misinterpreted as too low or too high due to improper timing
  - Acetaminophen Toxicity
    - False interpretation if drawn too soon or too late
  - Digoxin Level
    - 12 hours to distribute into tissues / false high if drawn too soon
  - Not waiting long enough post fatty meal to perform BS, Triglycerides, Cholesterol levels
- **Medications**
  - Pseudoephedrine or Concerta showing up as illicit amphetamines
- **Incomplete**
  - Not enough serum for the procedure
- **Technical errors, procedures, reagents**
  - Decimal place errors when reporting
  - Wrong patient name on vial
  - Drawing Nutrition support labs or serum drug levels out of the same port into which the drug/TPN is being administered
- **Diet**

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## Units of Measure

- Conventional units
- SI units
- Example:

<u>Conventional glucose</u>	<u>SI unit glucose</u>
70-110 mg/dL	3.9 - 6.1 mmol/L

Be sure to note which units are being referred to when reading journal articles about diseases and therapy. USA and other countries do not always follow same reporting structure.

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## Blood Chemistry

- **BMP (Basic Metabolic Panel, SMA-6)**
  - analyzes Na, K, Cl, CO<sub>2</sub>, BUN, glucose
  - insights into serum electrolytes, acid-base status, renal function and metabolic state
- **Chem Panel-12 (SMA-12)**
  - add: albumin, total protein, bilirubin, alk phos, calcium and creatinine
  - more specific renal evaluation, and liver function, nutritional parameters
  - **Missing for Nutritional needs is Mg, PO4, Pre-Albumin, Triglycerides**
- **Chem Profile-20 (CMP)**
  - Add: phosphorus, cholesterol, triglycerides, uric acid, iron, lactate dehydrogenase (LD), aspartate aminotransferase (AST), and alanine aminotransferase (ALT)
  - Additional metabolic information, cardiovascular risk, and liver function
  - **Missing is MAGNESIUM**

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## Blood Chemistry (cont.)

- **Magnesium and Phosphate**
  - Very important electrolytes that are frequently missing in basic panels
  - Both cause problems in managing other electrolytes if not assessed appropriately
- **Magnesium**
  - Catalyst for the Na-K-ATP Pump
- **Phosphate**
  - Vital component in all enzyme actions and the ATP Pump

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## Blood Gases and Acid-Base

- **Critical Care Panel**
  - ABG (arterial blood gas: pCO<sub>2</sub>, pO<sub>2</sub>, pH, HCO<sub>3</sub>)
  - Ionized Calcium
  - Magnesium
  - BMP (Na, K, Cl, CO<sub>2</sub>, BS, BUN, Creatinine)
- Very important to interpret all the above in concert
  - Increased pH → Acidemia → expect higher than norm K
  - Decreased pH → Alkalemia → expect lower than norm K
- pH, pCO<sub>2</sub>, pO<sub>2</sub>
- Ventilator management, toxicology management, critical care management, COPD management, DKA management, etc...

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## Hematology and Coagulation

- **RBC, hematocrit (Hct), hemoglobin (Hgb), MCH, MCV, MCHC**
  - Anemias
  - Macrocytic
  - Microcytic
  - Do we use IRON or do we use FOLIC ACID / B-12 or do we use Erythropoietin or do we combine all the above?
  - Acute onset vs chronic onset?
  - Do we transfuse or not?
- **WBC/differential**
  - Bacterial vs Viral
  - Drug-Induced adverse effect
- **Platelets**
  - Thrombocytopenia → idiopathic?
  - Thrombocytopenia → drug induced?
- **ESR**
  - Inflammation vs not?
  - Allergic reaction?
- **PT, aPTT, fibrinogen**
  - Therapeutic drug ?
  - Liver function ?
  - Disseminated intravascular coagulation?
  - How to stop the bleed ?

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## Therapeutic Drug Monitoring

- **Infectious Disease:** aminoglycosides (amikacin, gentamicin, tobramycin), vancomycin
- **Pulmonology:** aminophylline, theophylline
- **Cardiology:** lidocaine, procainamide, propranolol, quinidine, digoxin, digitoxin, BNP, thiocyanate
- **Neurology:** carbamazepine, phenobarbital, phenytoin, antiepileptics in general
- **Psychiatry:** valproic acid

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## Drug Levels

- **Clinical importance**
  - Maintain safest parameter for best therapeutic outcome
- **Influenced by many factors**
  - Compliance,
  - Interaction,
  - Demographics,
  - Clinical condition,
  - Timing of administration/collection)
- **NO NORMAL levels in human body**, thus each person may be affected slightly different than another
  - Digoxin is prime example
  - 2 % of population will be toxic within therapeutic range

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## Drug Levels (cont.)

- **Peak level**
  - highest concentration detected between doses, within the post distribution phase
- **Trough level**
  - Lowest level detected prior to next dose
- **Sub-Therapeutic Range**
  - Level below which no therapeutic effects will be seen
- **Therapeutic Range**
  - lowest level of effectiveness extending to the highest level of effectiveness without toxicity
- **Toxic Range**
  - Levels above which the toxic effects manifest quite often
- **Toxic effects from commonly monitored drugs**
  - Antibiotics
  - Bronchodilators
  - Anticonvulsants
  - Cardiac glycosides
- **Evaluate in conjunction with Renal function, Hepatic Function, Cardiac Function, Hydration status, Patient signs/symptoms**

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### Disease States—Frequently Monitored Values

- Indicate effectiveness of therapeutic regimen
- Current status and underlying disease state evaluation
- Commonly used indicators for:
  - diabetes
  - CHF
  - asthma
  - cancer
  - nutrition

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### Diabetes

- Blood glucose
- Acid/base
- Glycosylated hemoglobin (HgbA1C)

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### Diabetes—Criteria for Admission

- **DKA: blood glucose >250mg/dL (>13.9mmol/L) and**
  - venous pH <7.3 or serum bicarb level <15 MEq/l
  - ketonuria and/or ketonemia
- **Uncontrolled diabetes**
- **Hyperglycemia with volume depletion**
  - recurring blood glucose >300 mg/dL
  - recurring episodes of hypoglycemia, or unstable hyper- and hypoglycemic episodes

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## Diabetes—Ongoing Assessment

- Blood glucose
  - trends information (daily basis) for adjustments in therapy regimen
- Glycosylated hemoglobin (HgbA1C)
  - predicts risk for development of chronic complications
  - measured every 3 months
  - goal:  $\leq 7\%$ , reevaluate treatment regimen if  $>8\%$

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## Asthma

- Peak flow
  - PEF based on “personal best” established over 2-3 weeks of measurement
  - PEF  $< 80\%$  indicates need for additional meds
  - PEF  $< 50\%$  indicates a severe asthma exacerbation
- Drugs:
  - routine monitoring of serum theophylline is important in long-term control
  - zileuton (leukotriene modifier), monitor hepatic enzymes (ALT)
- IgE level:
  - Allergic asthma
  - Rx: Omalizumab

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## Congestive Heart Failure

- Drug levels (e.g. digoxin)
  - Critical following the addition of amiodarone
  - Critical following decrease in renal function
  - Critical as patient ages and renal function declines
- BNP: also known as: b-type natriuretic peptide, proBNP
  - Greater than 400 may suggest possible decompensated CHF and need for niseritide (Natrecor)
- Fluid/electrolyte, BUN, creatinine, BUN:Cr ratio, Mg
  - Frequent cause of hyponatremia (SIADH), prerenal azotemia and dysfunction, electrolyte loss due to diuretic and natriuretic therapy
- Anticoagulant labs (INR) as appropriate
  - concomitant atrial fibrillation (INR 2-3 x control)
  - history of embolism (INR 2-3.8 x control)

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## Cancer

- **CBC, platelets**
  - Chemotherapy knocks out fast growing cells, including WBC, Platelets
  - Knowing the NADIR of the chemo regimen assists in determining when to cycle up again or if Hematopoetic stimulation should take place with medication
- **CEA (carcinoembryonic antigen)**
  - <2.5-10 ng/mL
  - Generally detected in Gastrointestinal Cancers, but other cancers show positive levels
  - Elevated in presence of benign or malignant diseases
  - Sequential levels are helpful in following patients with tumor
  - Are elevated shortly after chemo or radiation therapy due to debulking tumor and release of antigen
- **ANC Absolute Neutrophil Count (Rx marker)**
- **PSA (prostate-specific antigen)**
  - Benign prostatic hypertrophy
  - Prostatic cancer
  - Normal range differs in age groups → increases as age increases

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## Nutritional Status

- **Albumin (required level Medicare TPN)**
- **Pre-Albumin**
- **Total Protein**
- **TIBC**
- **Total lymphocyte count (% of WBC)**
- **HGB/Hct**
- **Electrolytes**
- **Triglycerides**
- **Blood Sugar**
- **Serum bicarbonate**
- **LFT**
- **Pulmonary function tests**

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## Case Management Implications

- Are necessary lab values ordered by the physician?
- Are medications adjusted according to lab values?
- Are tests being ordered unnecessarily?
- Are tests being used to monitor underlying disease states?
- Providers should document information and pass on to the case manager as requested.

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### Questions?

1. *T/F?* Routine tests of serum, urine and other body fluids should be performed when assessment of those values will affect decisions in therapeutic management.
2. *T/F?* Normal lab values vary from one lab to another, for consistency, use the reference values from the lab performing the tests.
3. *T/F?* Drug classifications that require periodic monitoring for therapeutic effectiveness include aminoglycosides, bronchodilators, anticonvulsants and cardiac glycosides.
4. *T/F?* Sequentially elevated CEA levels in a patient with a history of cancer may indicate increased tumor activity.
5. *T/F?* A glycosylated hemoglobin level of 6.8% indicates adequate blood glucose control in a diabetic patient.



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Thank You!!

Questions?

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