MEDAVIE HealthEd ÉduSanté

Interpretation of Lab and Basic Diagnostic Tests

Advanced Care Paramedicine

Module: 12
Section: 02a

Introduction

- Many patients will have had diagnostic tests performed before interfacility transport
  - Provide valuable patient information
- Must have basic understanding of common lab tests
- Three types of tests commonly performed
  - Laboratory tests
  - Imaging studies
  - Physiologic tests
- Some results available immediately, others can take days

Laboratory Tests

- Studies or assays performed on body tissues
  - Stool
  - Urine
  - Blood
  - Spinal fluid
- Abnormal values
  - Fall outside the reference range

Laboratory Tests

- Categories of lab tests
  - Hematology
  - Chemistry
  - Microbiology
  - Serology
  - Pathology

Laboratory Values

- Quantitative
  - Numerical value
- Qualitative
  - Yes/no
- Normal reference values
  - Established over years
  - Gaussian distribution
  - Percentile ranking system
  - Values vary with:
    - Age
    - Sex

Specificity

- Measure of how well a test detects a disease
- Test that is 100 percent specific will detect disease in 100 percent of individuals who have it
  - Test with high specificity has few false positives
  - A very specific test will mean if you have a positive test, you are highly likely to have the disease.
  - Few tests are 100 percent specific

Sensitivity

- Degree to which a test detects disease without yielding a false negative result
  - Test with high sensitivity has few false negatives
  - A very sensitive test will mean if you have a negative test, you are very unlikely to have the disease.
  - No test is 100 percent sensitive

Lab Value Measurement

- Metric system
  - Small quantities measured
  - Picogram (pg)
  - Nanogram (ng)
  - Milliequivalents (mEq)

Common Multiples, Submultiples, and Prefixes		
MULTIPLES AND SUBMULTIPLES	PREFIX NAME	PREFIX SYMBOL
$1\,000\,000\,000\,000 = 10^{12}$	tera	T
$1\,000\,000\,000 = 10^{9}$	giga	G
$1\,000\,000 = 10^{6}$	mega	M
$1\,000 = 10^{3}$	kilo	k
$100 = 10^{2}$	hecto	h
$10 = 10^{1}$	deka	da
$1 = 10^{0}$	Base Unit	
$0.1 = 10^{-1}$	deci	d
$0.01 = 10^{-2}$	centi	c
$0.001 = 10^{-3}$	milli	m
$0.000\,001 = 10^{-6}$	micro	μ
$0.000\,000\,001 = 10^{-9}$	nano	n
$0.000\,000\,000\,001 = 10^{-12}$	pico	p

Lab Value Measurement

- SI units
  - Concentrations reported as amount per unit volume
    - Moles, millimoles per liter
    - Mol or mmol/L

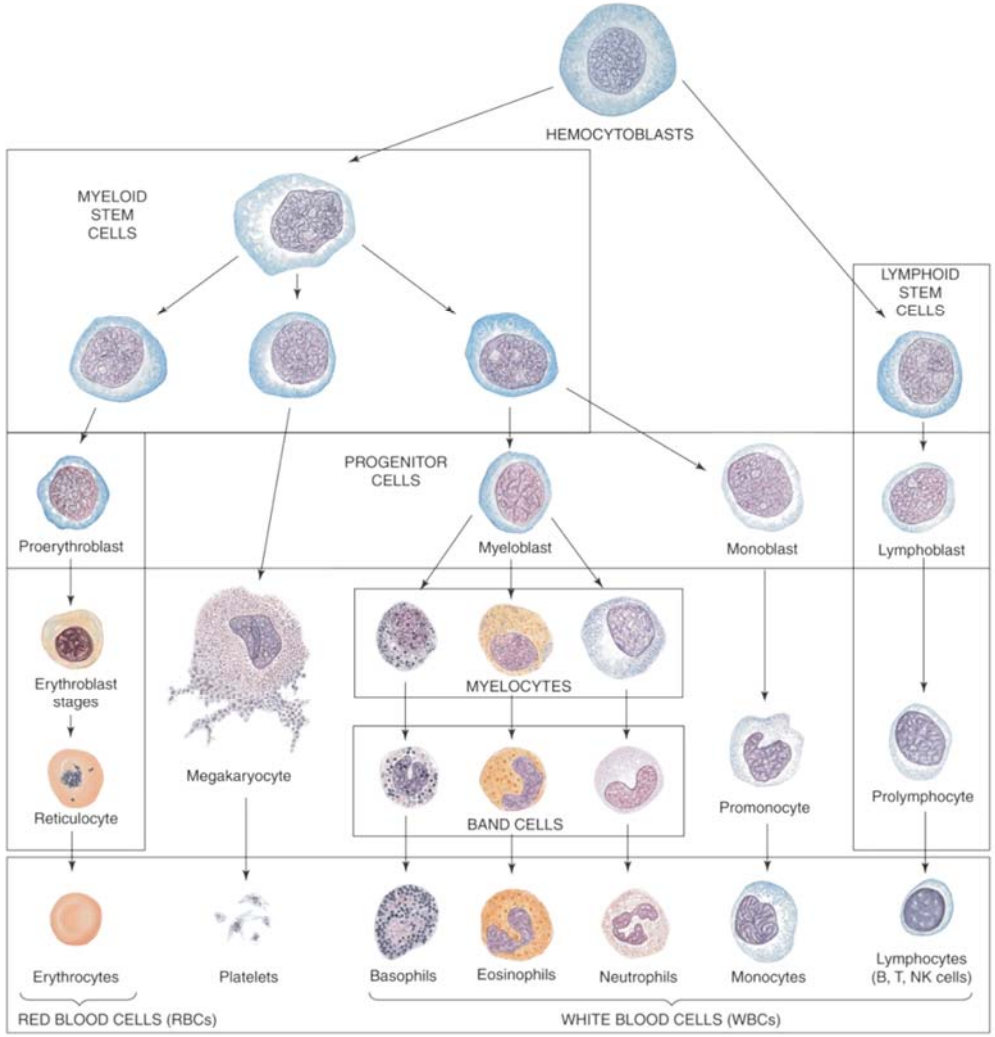
Lab Specimen Collection

- Blood collected in vacuum tubes
  - Different tubes contain different substances
    - Preservatives
    - Anticoagulants
  - Different preparations identifiable by color
  - Tubes filled in specific order to ensure accuracy
  - Specific tests require blood collection in specific tubes
    - Blood cultures (yellow tops)
    - Nonadditive tubes (red tops)
    - Coagulation tubes (light blue tops)
    - Serum separator tubes (tiger tops)
    - Heparin tubes (green tops)
    - EDTA tubes (lavender tops)
    - Oxalate fluoride (gray tops)

Hematology

- Study of blood and its elements
  - Automated
- CBC (complete blood count) is used to assess 3 things:
  - **Hemoglobin**, or other measures of red blood cell count.
  - **White blood cell count**, and the differential break down of this.
  - **Platelet count**.

Hematopoietic cell line

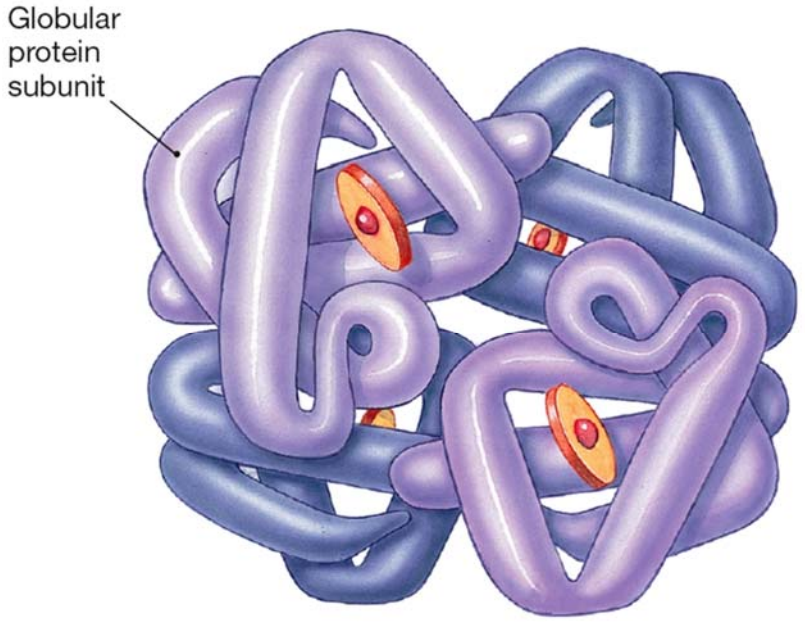


Complete Blood Count (CBC)

- The following measures are all used to reflect **red blood cell count** and size/characteristics:
  - Hemoglobin
  - Hematocrit
  - Red blood cell number
  - MCV, MCH, MCHC
  - RDW
  - Reticulocyte count
- These values allow qualtification of an abnormal hemoglobin level, as well as clues as to the underlying etiology.
- The most important one to interpret is the **hemoglobin level** itself.

Complete Blood Count (CBC)

- Hemoglobin
  - Significance
    - Amount of hemoglobin in blood
  - Normal value
    - Men: 130 – 180 g/L
    - Women: 120 – 160 g/L
  - High value
    - History of smoking
  - Low value
    - Anemia
    - Blood loss
    - Overhydration



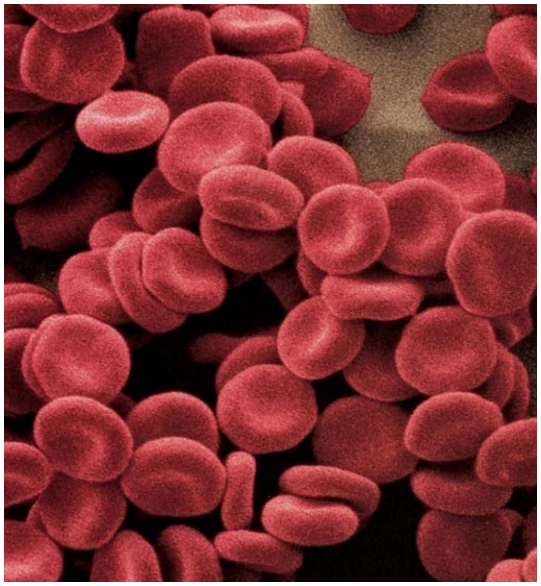
(c) Hemoglobin

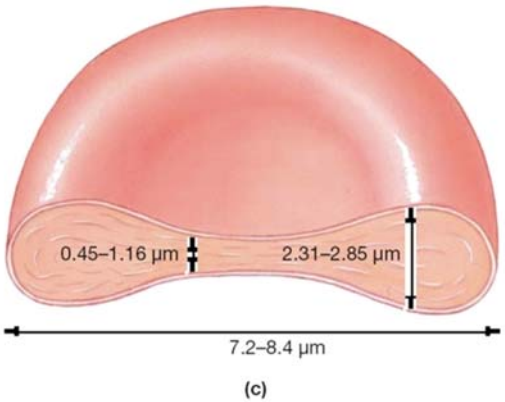
Complete Blood Count (CBC)

- Hematocrit
  - Significance
    - Percentage of red blood cells (RBCs) in the plasma
  - Normal value
    - Men: 37 to 49 percent
    - Women: 36 to 46 percent
  - High value
    - Dehydration
    - Polycythemia
  - Low value
    - Overhydration
    - Anemia
    - Blood loss

Complete Blood Count (CBC)

- Red blood cell (RBC)
  - Significance
    - Number of RBCs per cubic millimeter of blood
  - Normal value
    - Men: 4.5–5.3 million/mm^3
    - Women: 4.1–5.1 million/mm^3
  - High value
    - Polycythemia
    - High altitudes
  - Low value
    - Bone marrow suppression
    - Abnormal loss/suppression of erythrocytes





From Essentials of Anatomy & Physiology, 2nd ed., by Frederick H. Martini, Ph.D. and Edwin F. Bartholomew, M.S. Copyright © 2000 by Frederic H. Martini, Inc. Published by Pearson Education, Inc.

Complete Blood Count (CBC)

- Mean corpuscular volume (MCV)
  - Significance
    - RBC size
  - Normal value
    - Men: 78–100 Ñm^3
    - Women: 78–102 Ñm^3
  - High value
    - Folic acid deficiency
    - Vitamin B12 deficiency
    - Alcoholism
  - Low value
    - Iron-deficiency anemia
    - Lead poisoning

Complete Blood Count (CBC)

- Mean corpuscular hemoglobin (MCH)
  - Significance
    - Amount of hemoglobin in one RBC
  - Normal value
    - 25–35 pg (male and female)
  - High value
    - Folic acid deficiency
    - Vitamin B12 deficiency
  - Low value
    - Iron-deficiency anemia
    - Thalassemias

Complete Blood Count (CBC)

- Mean corpuscular hemoglobin concentration (MCHC)
  - Significance
    - Proportion of each cell occupied by hemoglobin
  - Normal value
    - 31 to 37 percent (male and female)
  - High value
    - Folic acid deficiency
    - Vitamin B12 deficiency
  - Low value
    - Iron-deficiency anemia
    - Thalassemias

Complete Blood Count (CBC)

- Red blood cell distribution width (RDW)
  - Significance
    - Measures the degree of anisocytosis
  - Normal value
    - 11.5 to 14.0 percent (male and female)
  - Reflects the breadth of different sizes of RBCs present (anisocytosis).
  - If the RDW is high, there may be both small and large RBCs present, reflecting mixed etiology to the low hemoglobin.

Reticulocyte Count

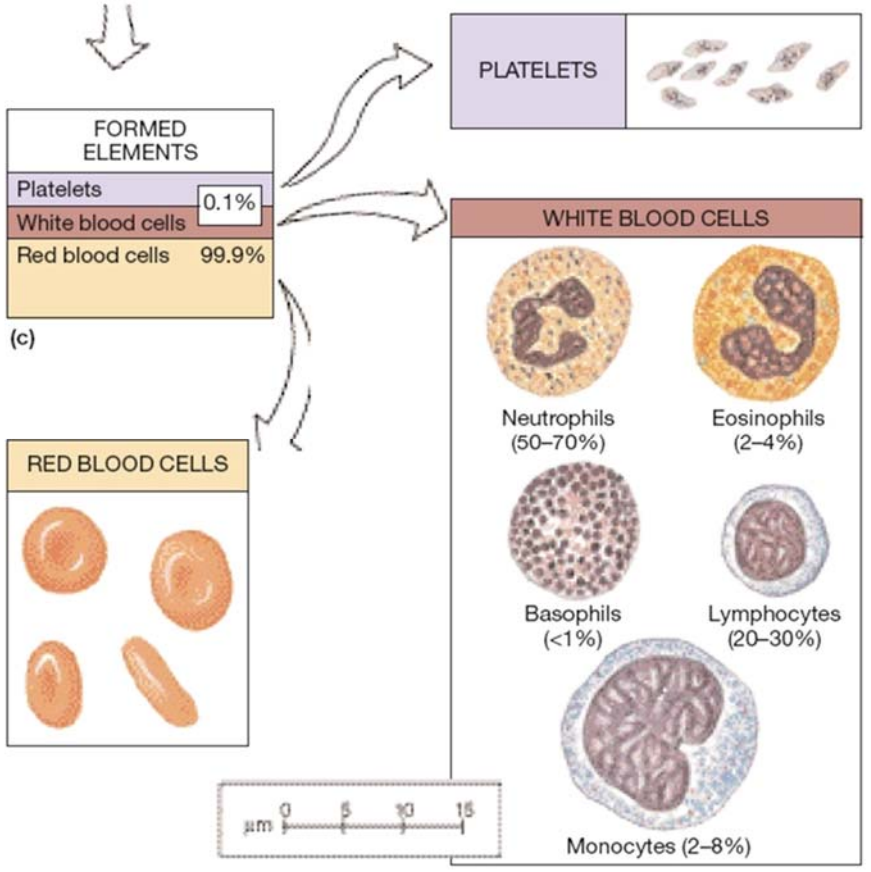
- Significance
  - Measures less mature types of RBCs
- Normal value
  - 0.5 to 2.5 percent of total RBC count (male and female)
- High value
  - Increased bone marrow RBC production
- Low value
  - Bone marrow RBC production suppression

In Summary:

- Red blood cell parameters:
  - Feel confident interpreting hemoglobin levels and what an abnormal level reflects.
  - Be aware of the other parameters reviewed.
- Questions?

Complete Blood Count (CBC)

- White blood cell (WBC)
  - Significance
    - Number of WBCs per cubic millimeter of blood
  - Normal value
    - 4.0 – 10.0 X 10^9/L (male and female)
  - High value
    - Infection
    - Leukemia
    - Steroids
  - Low value
    - Viral infection
    - Immunodeficiency



From Essentials of Anatomy & Physiology, 2nd ed., by Frederick H. Martini, Ph.D. and Edwin F. Bartholomew, M.S. Copyright © 2000 by Frederic H. Martini, Inc. Published by Pearson Education, Inc.

WBC Differential:

- Percentage of mature neutrophils (PMNs/Segs)
  - Significance
    - Percentage of segmented or mature neutrophils
  - Normal value
    - 2 – 7 X 10^9/L (male and female)
  - High value
    - Bacterial infection
    - Severe stress
  - Low value (neutropenia)
    - Cancer
    - Bone marrow depression (ie due to chemotherapy)

WBC Differential:

- Neutrophil Count
  - 2.0 – 7.0 X 10^9/L is normal
  - Higher levels occur with infection
  - Less than 0.5 X 10^9/L is referred to as "neutropenia" = immunocompromised.
  - Neutropenia is commonly caused by chemotherapy.
  - "Febrile neutropenia" is a time sensitive emergency, typically seen in a chemotherapy patient.

WBC Count Differential:

- Bands
  - Significance
    - Percentage of young or immature neutrophils
  - Normal value
    - < 0.7 X 10^9/L (male and female)
  - High value
    - Suggests a need for increased production of WBCs to "fight off" infection (ie bacterial infection)

Differential

- Eosinophils
  - Significance
    - Percentage of eosinophils
  - Normal value
    - < 0.45 X 10^9/L (male and female)
  - High value
    - Leukemia
    - Parasite infection
  - Low value
    - Corticosteroid therapy

Differential

- Basophils
  - Significance
    - Percentage of basophils
  - Normal value
    - < 0.10 X 10^9/L (male and female)
  - High value
    - Leukemia
    - Poorly understood
  - Low value
    - Corticosteroid therapy
    - Allergic reaction

Differential

- Lymphocytes
  - Significance
    - Percentage of lymphocytes
  - Normal value
    - 1.5 – 3.4 X 10^9/L (male and female)
  - High value
    - Viral infections
    - Leukemia
  - Low value
    - HIV infection/AIDS
    - Autoimmune disease

Differential

- Monocytes
  - Significance
    - Percentage of monocytes
  - Normal value
    - 0.14 – 0.86 X 10^9/L (male and female)
  - High value
    - Tuberculosis
    - Protozoan infections
    - Leukemia
  - Low value
    - Overwhelming infections
    - Following the administration of glucocorticoids

Left Shift

- Increased Segs and Bands
- Suggests bacterial infection

Right Shift

- Increased lymphocytes
- Suggests viral infection

In Summary

- White Blood Cell Count
  - Be able to interpret an abnormally high or low WBC count and understand what this means in terms of possible etiologies.
  - Most critical value on the differential is **neutrophil count**. Low neutrophils in a febrile patient represents a time sensitive emergency (**febrile neutropenia**).
  - Elevated lymphocytes often reflect viral infections.
  - Basophil, eosinophil, monocyte counts have little relevance during emergency care and for most patients in general.

Platelet Count

- Normal: 130 – 400 X 10^9/L
- Platelets are required for blood clotting.
- Low platelets (**thrombocytopenia**) predisposes patients to bleeding.
- Elevated platelets (**thrombocytosis**) can occur due to malignancies or non-specific inflammatory processes.
- Platelet transfusions may be required for low platelet counts or during a massive blood transfusion.

In Summary

- Complete Blood Count
  - RBCs (Hemoglobin)
  - WBCs (check neutrophils as well)
  - Platelet count
- Be familiar with the above, and what abnormalities represent.
- The other parameters are less relevant.

MEDAVIE HealthEd ÉduSanté

Erythrocyte Sedimentation Rate

ESR

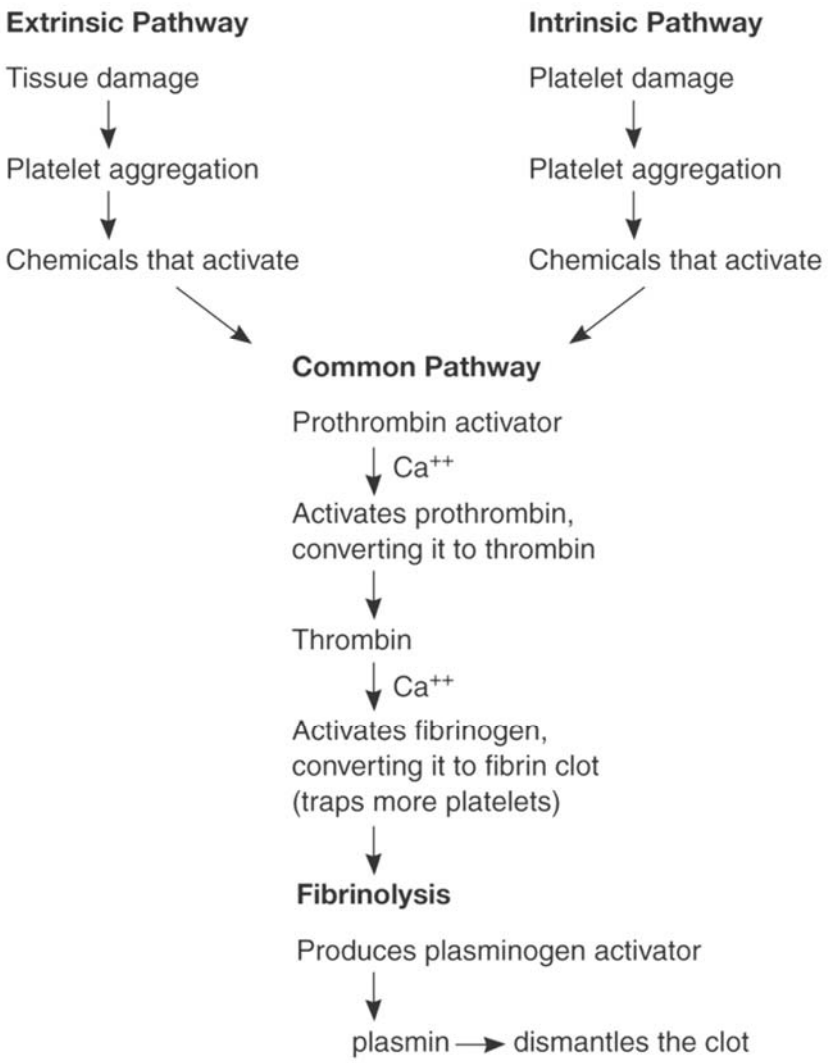
Erythrocyte Sedimentation Rate

- Not actually a reflection on the hematologic system.
- Reflects the rate of RBC sediment in a period of one hour
- Very non-specific measurement of inflammation (large number of causes of an elevated level)
- Normal value
  - 0 – 17 mm/hr (for men and women)
- Almost any cause of inflammation will cause an elevated ESR.
- Uses: rheumatologic conditions.

MEDAVIE HealthEd ÉduSanté

Coagulation Tests

Coagulation Cascade:



Prothrombin Time (PT)

- Significance
  - Measures effectiveness of the extrinsic and common pathways, as well as the effect of coumadin anticoagulants
- Normal value
  - 11.2–13.2 seconds (male and female)
- High values
  - Liver cirrhosis
  - Vitamin K deficiency
  - Disseminated intravascular coagulation (DIC)
- Treatment
  - Vitamin K, fresh frozen plasma, octreotide.
- **In Canada, we use the "INR" instead of the PT as a measure of the above abnormalities.**

International Normalized Ratio (INR)

- Reports the PT in standardized form
- Compares against control
- Healthy patient not receiving anticoagulants
  INR = 1.0 (ranges 0.9 – 1.2)
- Patient receiving warfarin therapy, goal for INR is typically between 2 - 3 for most indications.
- The causes of an elevated PT also cause an elevated INR (see previous slide).
- An elevated INR puts patients at bleeding risk
- INR may be corrected with vitamin K, FFP, octreotide.

Partial Thromboplastin Time (PTT)

- Significance
  - Detects coagulation disorders in the intrinsic and common pathways of the coagulation cascade
- Normal value
  - 28 - 38 seconds (male and female)
- High value
  - Heparin therapy

Partial Thromboplastin Time (PTT)

- Low values
  - Not clinically
- Treatment
  - Decrease heparin dose
  - Protamine
  - Fresh frozen plasma

Factor VIII

- Used to diagnose hemophilia A

Factor IX

- Used to diagnose hemophilia B

von Willebrand factor (vWF)

- Used to diagnose von Willebrand disease

Fibrinogen

- Forms fibrin during blood coagulation
- This test is ordered in the setting of a suspected bleeding or clotting disorder, or acutely as part of a DIC screen.

Fibrin Split Products

- Measures products of fibrin clot breakdown
- Used to diagnose DIC

D-Dimer Screen

- Degradation products of cross-linked fibrin
- Very non-specific test (a variety of disorders may cause a positive test)
- Used to diagnose:
  - Abruptio placenta
  - DIC
  - Deep venous thrombosis (DVT)
  - Pulmonary embolism

Thrombin Time

- Time to blood clotting when fibrin is added

Plasminogen Assay

- Plasminogen is the inactive precursor of plasmin
- Used to diagnose DIC

In Summary

- Coagulation lab tests:
  - Be familiar with INR/PTT, differential diagnosis for abnormalities, and acute implications regarding treatment options.
  - Factor VIII, IX, VWF assays self explanatory.
  - D-dimer most commonly for DVT/PE screening test, very non-specific.
  - Fibrinogen, fibrin split products, thrombin time, and plasminogen assay will typically be seen ordered together as a “DIC Screen”.

OK LET'S PRACTICE!

- Insert copy of real CBC report with some abnormalities. For the next few slides have 3-4 CBCs to be interpreted. I need to get these.

- Insert copy of abnormal INR and discuss interpetation, as well as perhaps a case with an elevated d dimer.

BLOOD CHEMISTRIES

Chemistries

- Tests often run in “panels” that contain similar information
- Include:
  - Electrolytes
  - Renal function tests
  - Liver function tests
  - Glucose metabolism
  - Lipid metabolism
  - Cardiac enzymes and markers

Electrolytes

- Sodium – Na^+
  - Measures sodium level
  - Normal
    - 135–145 mEq/L (male and female)
  - High values
    - Dehydration
    - Excess saline administration
    - Exchange transfusion with stored blood
    - Impaired renal function

Electrolytes

- Low values
  - Overhydration
  - Sodium loss
  - Vomiting, diarrhea, sweating, GI suctioning
  - Increased renal sodium loss
  - Diuretics, DKA, Addison's disease, renal disease

Electrolytes

- Potassium – K^+
  - Measures serum potassium
  - Normal
    - 100–108 mEq/L (male and female)
  - High values
    - Renal failure
    - Excess K^+ replacement
    - Massive tissue damage
    - Associated with metabolic acidosis

Electrolytes

- Low values
  - Diuretics
  - Inadequate intake
  - Large steroid doses
  - Associated with metabolic alkalosis

Electrolytes

- Chloride Cl^-
  - Measures serum chloride
  - Normal
    - 100 – 108 mEq/L (male and female)
  - High values
    - Increased Na^+ level
    - Decreased HCO_3^- levels
    - Renal failure
  - Low values
    - Vomiting
    - Gastric suction
    - Diarrhea
    - Diuretic use

Electrolytes

- HCO_3^- Aka. Bicarb
  - Measures serum bicarbonate
  - Normal
    - 24–30 mEq/L (male and female)
  - High values
    - Base excess
    - Metabolic alkalosis
    - Loss of gastric contents
    - Diuretic use

Electrolytes

- Low values
  - Base deficit
  - Metabolic acidosis
  - Bicarbonate consumption
  - Bicarbonate loss
  - Increase in serum chloride level

Electrolytes

- Mg^{2+}
  - Measures magnesium
  - Normal
    - 1.4–1.9 mEq/L (male and female)

Electrolytes

- Ca^{2+}
  - Measures serum calcium
  - Normal
    - 4.3–5.3 mEq/L (male and female)
  - High values
    - False rise due to dehydration
    - Hyperparathyroidism
    - Malignant tumors
    - Immobilization
    - Thiazide diuretics
    - Vitamin D intoxication
  - Low values
    - Hypoparathyroidism
    - Chronic renal disease
    - Pancreatitis
    - Massive blood transfusions
    - Severe malnutrition
    - False decrease due to low albumin levels

Electrolytes

- Free Ca^{2+}
  - Measures ionized calcium
  - Normal
    - 4.64–5.28 mg/dL (male and female)
  - High values
    - Hyperparathyroidism
    - Metastatic bone tumor
    - Milk-alkali syndrome
    - Multiple myeloma
    - Paget's disease
    - Sarcoidosis
    - Tumors producing a PTH-like substance
    - Vitamin D intoxication
  - Low values
    - Hypoparathyroidism
    - Malabsorption
    - Osteomalacia
    - Pancreatitis
    - Renal failure
    - Rickets
    - Vitamin D deficiency

Electrolytes

- PO_4^-
  - Measures phosphate
  - Normal
    - 1.8–2.6 mEq/L (male and female)
  - High values
    - Hyperparathyroidism
    - Renal failure
    - Increased growth hormone
    - Vitamin D intoxication
  - Low values
    - Hyperparathyroidism
    - Diuresis
    - Malabsorption/malnutrition
    - Carbohydrate loading
    - Antacid abuse

Anion Gap

- Measures the difference between anions and cations in the blood
  - Anions
  - Chloride, bicarbonate
  - Cations
  - Sodium, potassium
  - $(Na^+ + K^+) - (Cl^- + HCO_3^-) =$ Anion Gap

Anion Gap

- Unmeasured anions in serum form “gap” when anions and cations are compared
  - Phosphates, lactates, ketone bodies, organic acids
  - Normal anion gap = 12–14 mEq
- Increased gap indicates acidosis
  - Increased ketone bodies, lactate, organic acids
- Decreased gap indicates alkalosis
  - Increased bicarbonate, decreased acids

MEDAVIE HealthEd ÉduSanté

Renal Function Tests

BUN

- Measures
  - Blood urea nitrogen
- Normal value
  - 2.5 – 8.0 mmol/L (male and female)
- High levels
  - Renal disease
  - Renal damage
  - Dehydration
  - Shock
  - CHF
  - GI bleeding
  - High protein diets
- Low level
  - Overhydration
  - Increased ADH secretion

Creatinine

- Measures blood creatinine level
- Normal value
  - Men: 70 – 120 µmol/L
  - Women: 50 – 90 µmol/L
- High values
  - Kidney disease
  - Nephrotoxic medications
- Low values
  - Low muscle mass
  - Muscle atrophy

BUN/Creatinine Ratio

- Measures BUN: creatinine ratio in the blood
  - Can help determine cause of nonnormal values
- Normal value
  - 10:1 (male and female)

BUN/Creatinine Ratio

- Ratio > 10:1
  - Meaning
    - Extrinsic renal disease
  - Causes
    - Decreased renal perfusion
    - Increased urea load
  - Treatment
    - Hydration
    - Obstruction removal
    - Foley catheter

BUN/Creatinine Ratio

- Ratio < 10:1
  - Meaning
    - Renal disease
  - Causes
    - Chronic renal failure
    - Decreased urea load
    - Inhibited creatinine secretion
    - Dialysis
  - Treatment
    - Cease administration of nephrotoxic medications
    - Dialysis

Creatinine Clearance Rate (CCR)

- Indicates glomerular filtration rate
- Best indicator of renal function
- $(UC \times UV)/SC = CCR$ (ml/minute/1.72 m^2 BSA)
  - UC = urine creatinine
  - UV = urine volume
  - SC = serum creatinine
  - 75 – 125 ml/min

Serum Osmolality

- Increases with dehydration
- Decreases with overhydration

Uric Acid

- Uric acid end-product of purine metabolism

Basic Metabolic Panel

- BUN
- Creatinine
- BUN/creatinine ratio
- Na^+
- K^+
- CL^-
- HCO_3^-
- Glucose

Glucose Metabolism Tests

- Blood glucose
  - Whole blood versus serum
    - Whole blood (male and female)
      - Average before meals = 80–120 mg/dL
      - Average at bedtime = 100–140 mg/dL
    - Plasma (male and female)
      - Average before meals = 90–130 mg/dL
      - Average at bedtime = 110–150 mg/dL

Glucose Metabolism Tests

- Glycohemoglobin (hemoglobin A1C)
  - Glycohemoglobin forms in periods of prolonged hyperglycemia
  - Measuring percent saturation indicates trend over previous 3–4 months
  - Normal values (male and female)
    - Nondiabetics = 4 to 6 percent
    - Diabetics = <7 percent
    - Good control = <7.5 percent
    - Fair control = 7.6 to 8.9 percent
    - Poor control = >9.0 percent

Lipid Metabolism Tests

- Cholesterol
  - Normal (male and female)
    - Desirable: <5.2 mmol/L
    - Borderline high: 5.2 – 6.2 mmol/L
    - High: >6.2 mmol/L
  - High levels
    - Cause often unknown
    - Dietary
    - Hereditary
    - Pregnancy
    - Pancreatic problems
  - Low levels
    - Hyperthyroidism
    - Severe liver damage
    - Malnutrition

Lipid Metabolism Tests

- Triglycerides
  - Normal (male and female)
    - Desirable: <2.20 mmol/L
  - High levels
    - Dietary
    - Hereditary
    - Pregnancy
    - Pancreatitis
    - Alcohol abuse
  - Low levels
    - Malnutrition
    - Medications

Lipid Metabolism Tests

- HDL
  - Low
    - < 1.0 mmol/L
  - High levels
    - Moderate alcohol intake
    - Exercise
    - Weight loss
  - Low levels
    - Diabetes mellitus
    - Menopause
    - Obesity

Lipid Metabolism Tests

- LDL
  - Desirable: < 3.0 mmol/L
  - If patient is:
    - Low risk:
      - LDL should be < 5.0 mmol/L (with total cholesterol < 6.0)
    - Moderate Risk:
      - LDL should be < 3.5 mmol/L (HDL-C < 5.0)
    - High Risk:
      - LDL should be < 2.0 mmol/L (HDL-C < 4.0)
  - High levels
    - High-fat diet
    - Hyperthyroidism
    - Nephrotic syndrome
    - Diabetes mellitus
    - Familial lipid disease
  - Low levels
    - Advanced liver disease
    - Malnutrition

Lipid Metabolism Tests

- VLDL
  - Normal
    - 10–31 mg/dL (male and female)
  - High levels
    - Diabetes
    - Obesity
    - Hepatic oversecretion

Cardiac Enzymes and Markers

- CK
  - Measures creatinine kinase
  - Normal
    - Men: 60–100 U/L
    - Women: 40–150 U/L
    - Isoenzymes
      - CK-1 (BB): 0 to 1 percent
      - CK-II (MB): <3 percent
      - CK-III (MM): 95 to 100 percent
  - High level
    - Muscle disease
    - Exercise
    - IM injections
    - Shock
    - Tumors
  - Low levels
    - No clinical significance

Cardiac Enzymes and Markers

- CK-MB
  - Measures creatinine kinase, myocardial band
  - Normal (male and female)
    - <10 u/L: MI improbable
    - 10–12 U/L: inconclusive
    - >12 U/L: MI probable
  - High levels
    - Myocardial damage
  - Low levels
    - No clinical significance

Cardiac Enzymes and Markers

- LDH
  - Measures lactase dehydrogenase
  - Normal
    - Adult: 40–90 U/L
    - Isoenzymes
      - LDH_1: 17 to 27 percent
      - LDH_2: 21 to 28 percent
      - LDH_3: 18 to 28 percent
      - LDH_4: 5 to 15 percent
      - LDH_5: 5 to 15 percent
  - High levels
    - Anemias elevate LDH_1 and LDH_2
    - Pulmonary embolism elevates LDH_3
    - Liver damage elevates LDH_4 and LDH_5
    - MI causes reversal of LDH_1 and LDH_2 ratio.
  - Low levels
    - No clinical significance

Cardiac Enzymes and Markers

- Myoglobin
  - Measures myoglobin
  - Normal (male and female)
    - 50–120 Ég/dL
  - High levels
    - Myocardial necrosis
  - Low levels
    - No clinical significance

Cardiac Enzymes and Markers

- Troponin
  - Measures troponin
  - Normal (male and female)
    - Troponin T
      - < 14 ng/L
  - High levels
    - Myocardial necrosis (Result > 50 ng/L or > 20 ng/L change from previous sample plus signs of ischemia)
  - Low levels
    - No clinical significance

Cardiac Enzymes and Markers

- BNP
  - Measures B-natriuretic peptide
  - Normal (male and female)
    - 5–100 pg/dL
  - High levels
    - Abnormal ventricular function
    - Congestive heart failure
  - Low levels
    - No clinical significance

Liver Function Tests

- Total bilirubin
  - Measures total bilirubin
  - Normal value (male and female)
    - 0.1–1.0 mg/dL
  - High value
    - Related to indirect and direct bilirubin levels
  - Low value
    - Not clinically significant

Liver Function Tests

- Indirect bilirubin
  - Measures unconjugated bilirubin
  - Normal value (male and female)
    - 0.1–1.0 mg/dL
    - Mean = 0.5 mg
  - High value
    - Sickle cell disease
    - Autoimmune disease
    - Hemorrhage
    - Drug toxicity
  - Low value
    - No clinical significance

Liver Function Tests

- Direct bilirubin
  - Measures conjugated bilirubin
  - Normal value (male and female)
    - 0.0–0.4 mg/dL
    - Mean = 0.1 mg/dL
  - High value
    - Obstructive jaundice
    - Gallstones
    - Congenital biliary tract abnormalities
    - -Medici cations
  - Low value
    - No clinical significance

Liver Function Tests

- ALP
  - Measures alkaline phosphatase
  - Normal value
    - Men: 45–115 U/L
    - Women: 30–100 U/L
  - High value
    - Bone abnormality
    - Liver abnormality
    - Eclampsia
  - Low value
    - Scurvy
    - Genetic defects
    - Excessive Vitamin D intake

Liver Function Tests

- GGT
  - Measures gamma-glutamyl transferase
  - Normal value
    - Men: 1–94 U/L
    - Women: 1–70 U/L
  - High value
    - Liver disease
    - Alcohol use
  - Low value
    - No clinical significance

Liver Function Tests

- Ammonia
  - Measures ammonia
  - Normal value (male and female)
    - 35065 Ég/dL
  - High value
    - Liver failure
    - Reye's syndrome
  - Low value
    - No clinical significance

Liver Function Tests

- ALT
  - Measures alanine transaminase (formerly SGPT)
  - Normal value
    - Men: 10–55 U/L
    - Women: 7–30 U/L
  - High value
    - Severe hepatitis
    - Cirrhosis
    - Mononucleosis
  - Low value
    - Liver failure

Liver Function Tests

- AST
  - Measures aspartate transaminase (formerly SGOT)
  - Normal value
    - Men: 10–40 U/L
    - Women: 9–25 U/L
  - High value
    - Myocardial infarction
    - Hepatitis
  - Low value
    - Liver failure

Liver Function Tests

- Aldolase
  - Measures aldolase
  - Normal value (male and female)
    - 0–7 U/L
  - High value
    - Muscular disorders
  - Low value
    - No clinical significance

Liver Function Tests

- Amylase
  - Measures amylase
  - Normal value (male and female)
    - < 160 U/L
  - High value
    - Pancreatitis
    - Pancreatic trauma
  - Low value
    - Pancreatic destruction

Liver Function Tests

- Lipase
  - Measures lipase
  - Normal value (male and female)
    - 3–19 U/L
  - High value
    - Pancreatitis
    - Pancreatic trauma
  - Low value
    - No clinical significance

Serological Testing

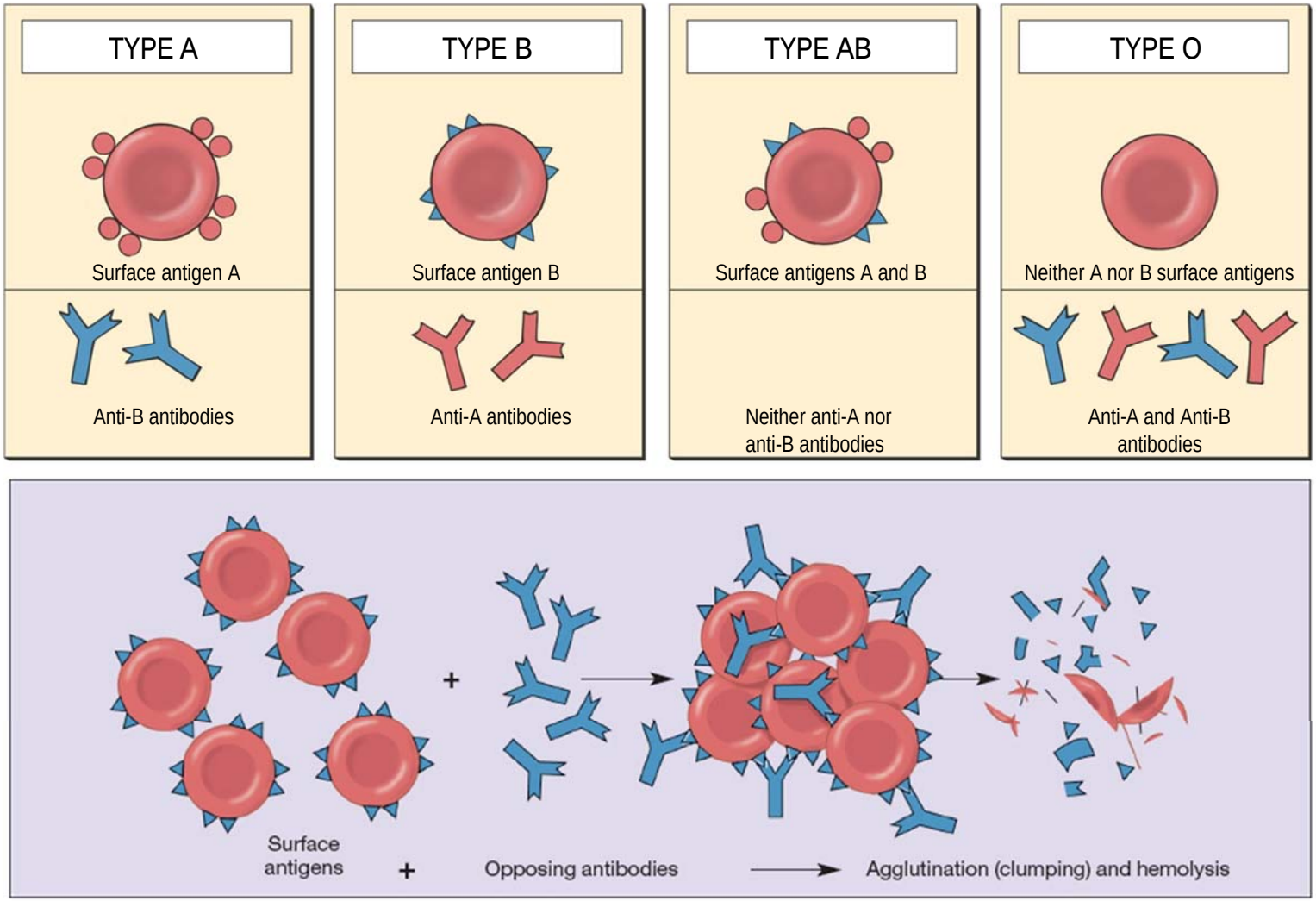
- Broad area of laboratory analysis
- Includes:
  - Blood banking
  - Microbiological serologic tests
  - Endocrine tests
  - Microbiology
  - Urinalysis

Blood Banking

- Several common tests for matching blood before administration
  - ABO typing
    - Identifies samples blood type
  - Rh factor
    - Identifies Rh antigen on RBCs
  - Direct Coomb's test
    - Measures antibodies on the RBC surface
  - Indirect Coomb's test
    - Measures antibodies to RBCs in blood serum

MEDAVIE HealthEd ÉduSanté

Blood Banking



From Essentials of Anatomy & Physiology, 2nd ed., by Frederick H. Martini, Ph.D. and Edwin F. Bartholomew, M.S. Copyright © 2000 by Frederic H. Martini, Inc. Published by Pearson Education, Inc.

Microbiological Serologic Tests

- Common tests include:
  - VDRL
    - Screening test for syphilis bacterium
  - RPR
    - Screening test for syphilis bacterium
  - FTA-ABS
    - Confirmation test for syphilis
  - MHA-TP
    - Confirmation test for syphilis

Microbiological Serologic Tests

- Common tests include:
  - HBsAg
    - Confirmation test for Hepatitis B virus
  - Anti-HAV
    - Measures Hepatitis A antibodies
  - Anti-HCV
    - Measures Hepatitis C antibodies

Microbiological Serologic Tests

- Common tests include:
  - HIV
    - Measures antibodies and antigens to HIV
  - CMV
    - Screening test for cytomegalovirus
  - Monospot
    - Screening test for mononucleosis

MEDAVIE HealthEd ÉduSanté

Endocrine Tests

Cortisol

- Measures adrenal cortical function
- Normal value (male and female)
  - 110 – 607 nmol/L
- High value
  - Cushing's syndrome
  - Pituitary tumors
- Low value
  - Addison's disease

TSH

- Measures thyroid-stimulating hormone
- Normal value (male and female)
  - 0.5–5.0 µU/mL
- High value
  - Thyroid failure
  - Pituitary tumor
- Low value
  - Hyperthyroidism
  - Pituitary failure

T3

- Measures triodothyronine
- Normal value (male and female)
  - 3.5 – 6.5 pmol/L
- High value
  - Hyperthyroidism
- Low value
  - Hypothyroidism

Free T4

- Measures free thyroxine
- Normal value (male and female)
  - 8.5 – 15.2 pmol/L
- High value
  - Hyperthyroidism
- Low value
  - Hypothyroidism

MEDAVIE HealthEd ÉduSanté

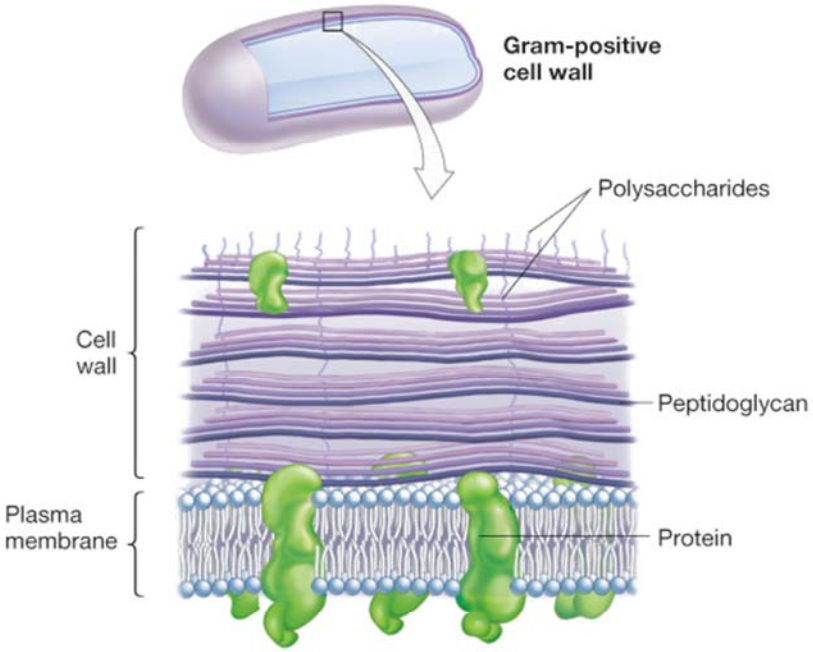
Microbiology

Gram Stain

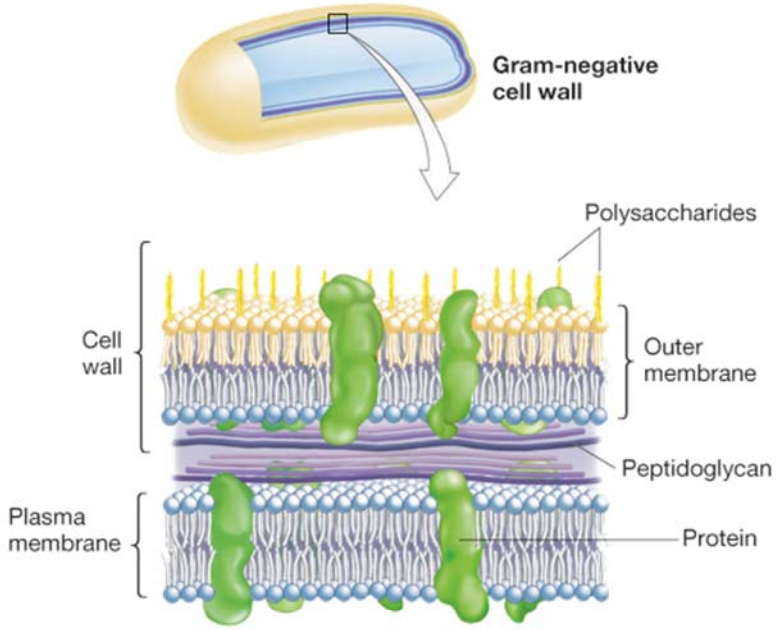
- Culture placed on microscope slide
- Reagents introduced to culture
  - Crystal violet
  - Gram's iodine solution
- Microorganisms take up stain based on nature of cell wall
- Slide examined under microscope

Gram Stain

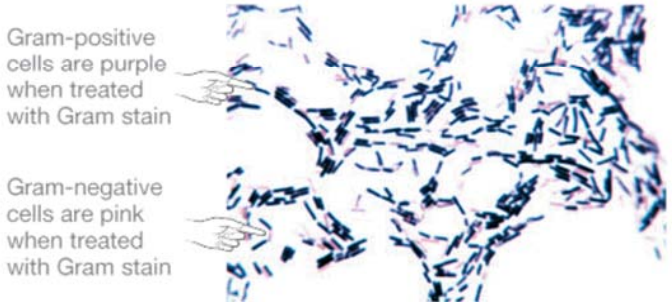
(a) Cell walls in Gram-positive bacteria have extensive peptidoglycan.



(b) Cell walls in Gram-negative bacteria have some peptidoglycan and an outer membrane.



(c) Gram-positive cells retain Gram stain more than Gram-negative cells do.



MEDAVIE HealthEd ÉduSanté

Urinalysis

pH

- Measures hydrogen ion concentration
  - Acidity of urine
- Normal value (male and female)
  - 5–9
  - Mean = 6
- High value
  - Urinary tract infection
  - Bicarbonate use
- Low value
  - Acidosis
  - Overhydration

Specific Gravity

- Measures urine concentration
- Normal value
  - Adult: 1.001–1.035
  - Child: 1.001–1.018
- High value
  - Dehydration
  - Increased ADH secretion
- Low value
  - Overhydration

Protein

- Measures protein in urine
- Normal value (male and female)
  - Negative
- High value
  - Renal disease
  - Pre-eclampsia/PIH
- Low value
  - No clinical significance

Sugar

- Measures sugars in urine
- Normal value (male and female)
  - Negative
- High value
  - Diabetes
  - Stress
- Low value
  - No clinical significance

Ketones

- Measures ketones in urine
- Normal value (male and female)
  - Negative
- High value
  - Malnutrition
  - DKA
  - Dieting
- Low value
  - No clinical significance

Nitrites

- Measures nitrites in urine
- Normal value (male and female)
  - Negative
- High value
  - UTI
- Low value
  - No clinical significance

Leukocyte Esterase

- Measures leukocyte esterase in urine
- Normal value (male and female)
  - Negative
- High value
  - UTI
- Low value
  - No clinical significance

Bilirubin

- Measures bilirubin in urine
- Normal value (male and female)
  - Negative
- High value
  - Liver disease
- Low value
  - No clinical significance

Urobilinogen

- Measures urobilinogen in urine
- Normal value (male and female)
  - Negative
- High value
  - Hepatic insufficiency
- Low value
  - No clinical significance

Casts

- Measures hyaline casts in urine
- Normal value (male and female)
  - Variable, very few present
- High value
  - Kidney dysfunction
- Low value
  - No clinical significance

Casts

Casts Found in Various Conditions	
Type of Cast	**Conditions**
Hyaline	Stenuous exercise Congestive heart failure Diabetic nephropathy Chronic renal failure (although not predominant type, seen in glomerulonephritis and pyelonephritis)
Red cell	Acute glomerulonephritis Lupus nehpritis Goodpasture syndrome Subacute bacterial endocarditis Renal infarct
White cell	Acute pyelonephritis Interstitial nephritis
Epithelial	Tubular necrosis Cytomegalovirus infection Heavy metal or salicylate toxicity Transplant rejection
Granular	Nephrotic syndrom Pyelonephritis Glomerulonephritis Transplant rejection Lead toxicity
Waxy	Severe tubular atrophy Renal failure Transplant rejection

WBCs

- Measures WBCs in urine
- Normal value (male and female)
  - <4–5 per HPF
- High value
  - Infection
- Low value
  - No clinical significance

RBCs

- Measures RBCs in urine
- Normal value (male and female)
  - <2–3 per HPF
- High value
  - Trauma
  - Infection
  - Kidney stones
- Low value
  - No clinical significance

Toxicology

- Tests for almost every substance
  - Some may be sophisticated, not readily available
- "Triage screens" for:
  - Opiates
  - Benzodiazepines
  - THC
  - Cocaine
  - Amphetamines
  - Barbiturates

Toxicology

- Tests also used to determine serum levels of medications
  - Identify different levels:
    - Subtherapeutic
    - Therapeutic
    - Toxic

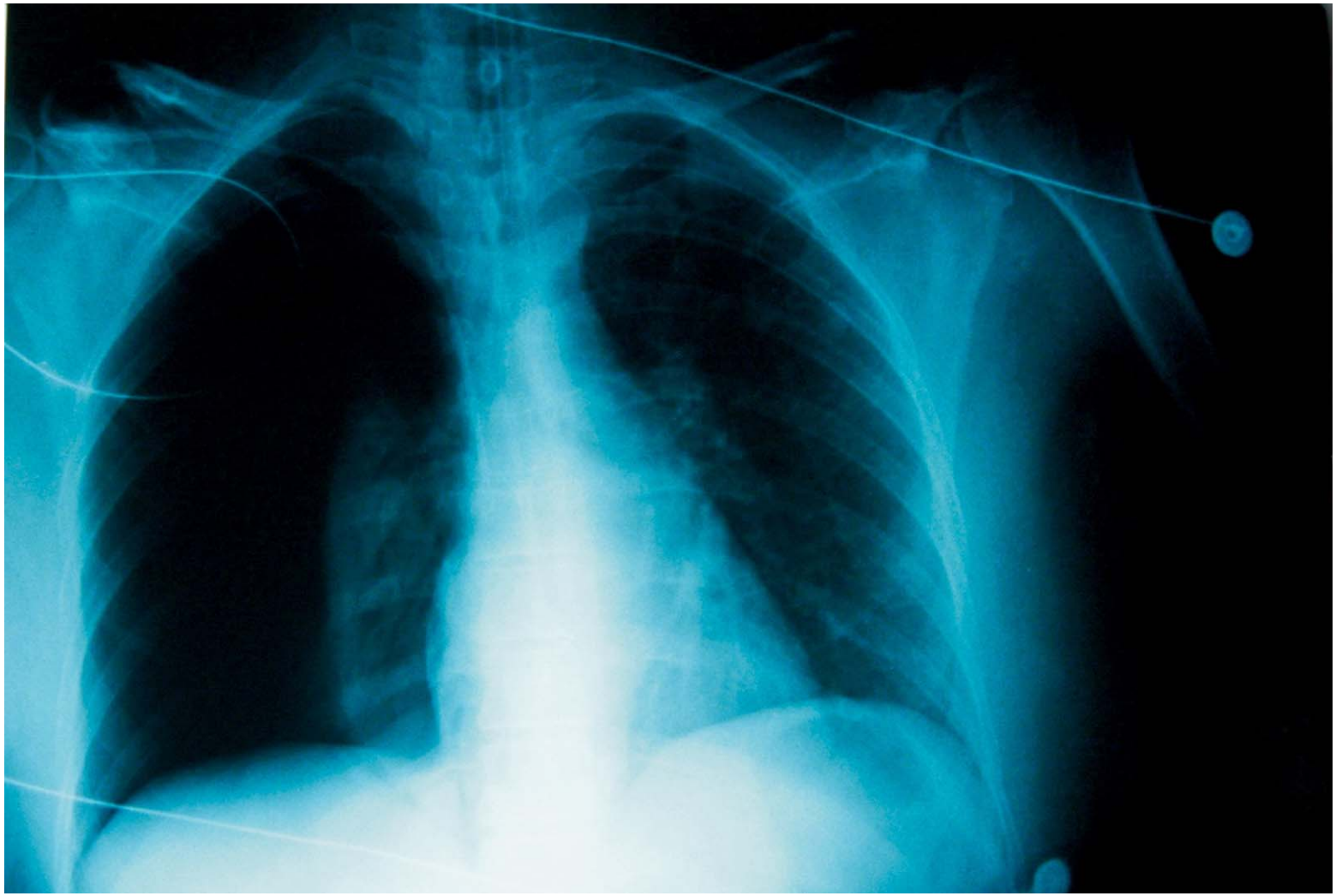
MEDAVIE HealthEd ÉduSanté

Imaging

X-Ray

- Primary examination tool for bones
  - Screening exam for chest
- Tissue density determines film exposure to X-rays
  - Bone = most dense = least film exposure = white on film
  - Air = least dense = most film exposure = black on film
- Contrast used to make tissues more visible
  - GI/GU tract

X-Ray



Edward T. Dickinson, M.D

Fluoroscopy

- X-ray and contrast media used for real-time imaging
- Image displayed on screen while fluroscope on

Computed Tomography (CT)

- Use focused x-rays to examine body tissue
- Computer used to enhance interpretation
- Sequential images, or “cuts,” displayed
  - Allow for detailed examination

Ultrasonography

- Sound waves transmitted through body tissue
  - More dense tissue reflects waves back to transducer
  - Computer interprets tissue density based on wave return
  - Image displayed on screen

Nuclear Medicine

- Radioisotope injected into patient
- Radioisotope movement recorded using nuclear medicine camera

Magnetic Resonance Imaging (MRI)

- Does not use ionizing radiation
- Strong magnetic field introduced around patient
  - Water molecules in tissues align along field
  - Magnetic field turned off, water molecules return to original orientation
  - Computer interprets tissue densities based on water movement

Magnetic Resonance Imaging (MRI)

- Excellent for tissue that contains water
  - Nervous tissue, joints, organs
- Poor for tissue containing little water
  - Bone

Positron Emission Tomography (PET)

- Produces information on organ function