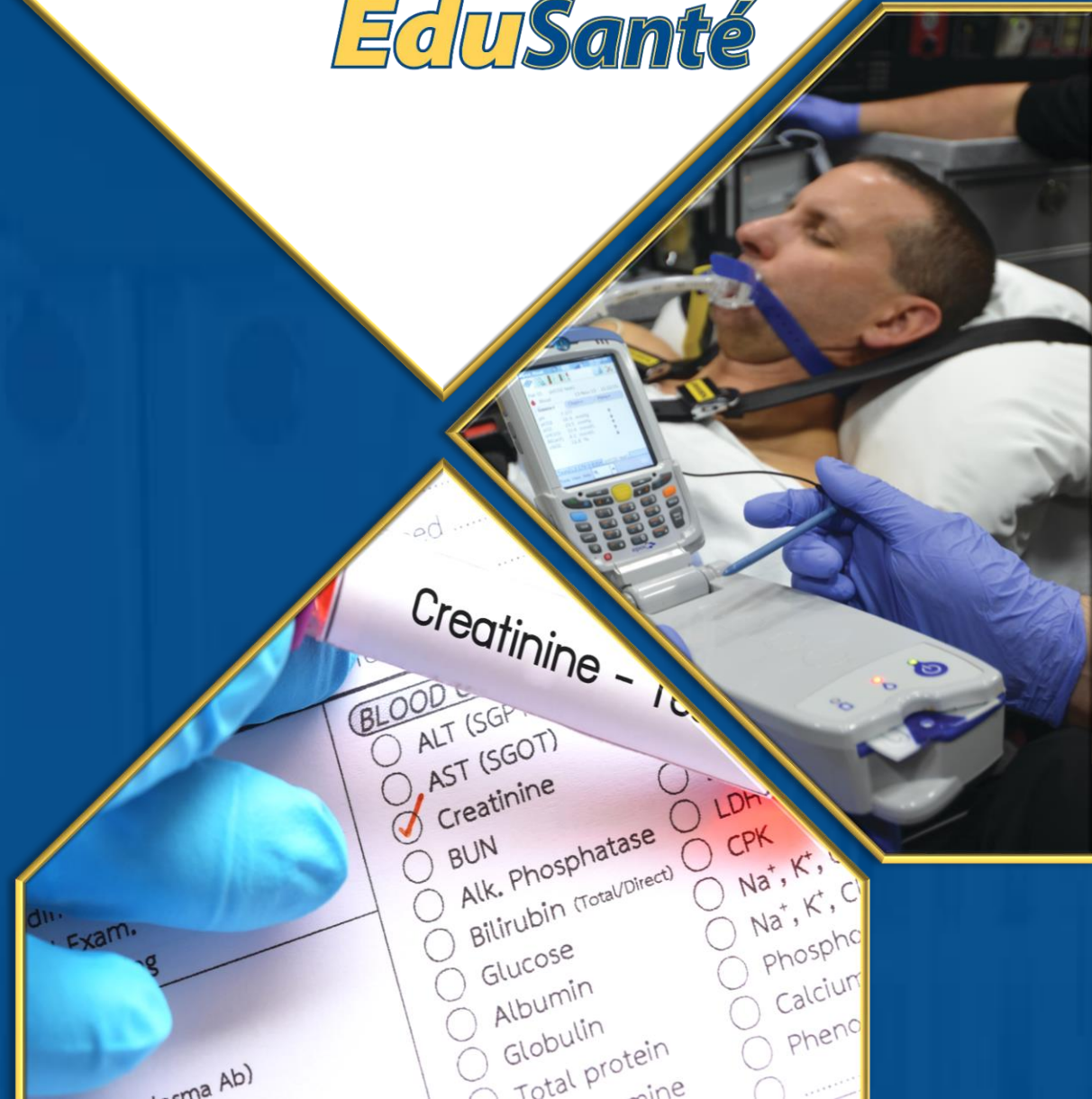


INTERPRETATION OF LAB VALUES AND BASIC DIAGNOSTIC TESTS

Primary Care Paramedicine

Module: 21
Section: 04



- 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

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

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

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

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

- 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)
 - Non-additive 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)

Interpretation of Lab Values and Basic Diagnostic Tests

HEMATOLOGY

- Study of blood and its elements
 - Automated



- CBC (complete blood count) is used to assess 3 things:
 - Hemoglobin (RBC count)
 - White blood cell count
 - Platelet count

Complete Blood Count (CBC)

Name	Normal Values	Low	High
RBC Count	<ul style="list-style-type: none"> M: 4.5–5.3 million/mm³ F: 4.1–5.1 million/mm³ 	Anemia, hemorrhage, certain leukemias, overhydration, chronic infections	Polycythemia, cardiovascular disease, hemoconcentration, dehydration
Hemoglobin (Hgb)	<ul style="list-style-type: none"> M: 13.0–18.0 g/dL F: 12–16 g/dL C: 10-17 g/dL 	Anemia, hyperthyroidism, liver disease, hemorrhage, hemolytic disease	COPR, Heart failure, polycythemia, high altitude sickness
Hematocrit (Hct)	<ul style="list-style-type: none"> M: 37% to 49% F: 36% to 46% 	As above including leukemia, lupus, endocarditis, rheumatic fever, nutritional disorders	Polycythemia and usually anything that produces severe dehydration
Platelet	130 – 400 X 10 ⁹ /L	Thrombocytopenia <ul style="list-style-type: none"> Predisposes patient to bleeding 	Thrombocytosis <ul style="list-style-type: none"> Can occur due to malignancies or non-specific inflammatory processes

WBC Count and Differential

Name	Normal Values	Low	High
WBC Count	<ul style="list-style-type: none"> 4,500–11,000/mm³ (M/F) 	Infection, Leukemia, Steroids	Viral infection, Immunodeficiency
Neutrophils (%)	<ul style="list-style-type: none"> 2 – 7 X 10⁹/L (M/F) Segmented and unsegmented 	Cancer, Bone marrow depression (i.e. due to chemotherapy)	Bacterial infection, Severe stress
Neutrophil Count	<ul style="list-style-type: none"> 2.0 – 7.0 X 10⁹/L (M/F) 	<ul style="list-style-type: none"> Less than 0.5 X 10⁹/L is referred to as “neutropenia” “Febrile neutropenia” is an emergency 	Infection
Basophils (also known as mast cells)	<ul style="list-style-type: none"> < 0.10 X 10⁹/L (M/F) 	Corticosteroid therapy, Allergic reaction	Leukemia, Poorly understood
Eosinophils	<ul style="list-style-type: none"> < 0.45 X 10⁹/L (M/F) 	Corticosteroid therapy	Leukemia, Parasite infection
Lymphocytes	<ul style="list-style-type: none"> 1.5 – 3.4 X 10⁹/L (M/F) 	HIV infection/AIDS, Autoimmune disease	Viral infections, Leukemia
Monocytes	<ul style="list-style-type: none"> 0.14 – 0.86 X 10⁹/L 	Overwhelming infections, Following the administration of glucocorticoids	Tuberculosis, Protozoan infections, Leukemia

- To determine if low oxygen levels or lactic acid in blood.
 - Drawn via vein or artery or CSF
 - Normal value: 0.5-1.8 mmol/L
 - Abnormal value: > 2.0 mmol/L
- Often ordered in cases of:
 - Shock
 - Heart attack
 - Respiratory failure
 - Sepsis
 - Kidney failure
 - Uncontrolled diabetes

- 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

Name	Normal Values	Low	High
Sodium (Na ⁺)	<ul style="list-style-type: none"> 135–145 mEq/L 	Overhydration, Sodium loss, Vomiting, diarrhea, sweating, GI suctioning, Increased renal sodium loss, Diuretics, DKA, Addison’s disease, renal disease	Dehydration, Excess saline administration, Exchange transfusion with stored blood, Impaired renal function
Potassium (K ⁺)	<ul style="list-style-type: none"> 100–108 mEq/L 	Diuretics, Inadequate intake, Large steroid doses, Associated with metabolic alkalosis	Renal failure, Excess K ⁺ replacement, Massive tissue damage Associated with metabolic acidosis
Chloride (Cl ⁻)	<ul style="list-style-type: none"> 95-108 mEq/L 	Vomiting, Gastric suction, Diarrhea, Diuretic use	Increased Na ⁺ level, Decreased HCO ₃ ⁻ levels, Renal failure
HCO ₃ ⁻ (Bicarb)	<ul style="list-style-type: none"> 24–30 mEq/L 	Base deficit, Metabolic acidosis, Bicarbonate consumption, Bicarbonate loss, Increase in serum chloride level	Base excess, Metabolic alkalosis, Loss of gastric contents, Diuretic use

Name	Normal Values	Low	High
Magnesium (Mg^{2+})	<ul style="list-style-type: none"> 1.4–1.9 mEq/L 	Hyperaldosteronism, Hypercalcemia, Kidney disease, Diarrhea, Medications (PPI, Diuretics, ABx), Pancreatitis, Diabetes, Preeclampsia, Ulcerative colitis	Hyperparathyroidism, Diuresis, Malabsorption/malnutrition, Carbohydrate loading, Antacid abuse
Calcium (Ca^{2+})	<ul style="list-style-type: none"> 4.3–5.3 mEq/L 	Hypoparathyroidism, Chronic renal disease, Pancreatitis, Massive blood transfusions, Severe malnutrition, False decrease due to low albumin levels	False rise due to dehydration, Hyperparathyroidism, Malignant tumors, Immobilization, Thiazide diuretics, Vitamin D intoxication
Free Calcium (Ca^{2+})	<ul style="list-style-type: none"> 4.64–5.28 mg/dL 	Hypoparathyroidism, Malabsorption, Osteomalacia, Pancreatitis, Renal failure, Rickets, Vitamin D deficiency	Hyperparathyroidism, Metastatic bone tumor, Multiple myeloma, Paget’s disease, Sarcoidosis, Tumors producing a PTH-like substance, Vitamin D Intoxication
Phosphate (PO_4^-)	<ul style="list-style-type: none"> 1.8–2.6 mEq/L 	Hyperparathyroidism, Diuresis, Malabsorption/malnutrition, Carbohydrate loading, Antacid abuse	Hyperparathyroidism, Renal failure, Increased growth hormone, Vitamin D intoxication

Interpretation of Lab Values and Basic Diagnostic Tests

RENAL FUNCTION TESTS

Name	Normal Values	Low	High
Blood urea nitrogen (BUN)	<ul style="list-style-type: none"> 8–15 mg/dL 	Overhydration, Increased ADH secretion	Renal disease, Renal damage, Dehydration, Shock, CHF, GI bleeding, High protein diets
Creatinine (Cr)	<ul style="list-style-type: none"> M: 0.6–1.4 mg/dL F: 0.6–1.1 mg/dL 	Low muscle mass, Muscle atrophy	Kidney disease, Nephrotoxic medications
BUN/Cr Ratio	<ul style="list-style-type: none"> 10:1 	Meaning: Renal disease Causes: Chronic renal failure, Decreased urea load, Inhibited creatinine secretion, Dialysis	Meaning: Extrinsic renal disease Causes: Decreased renal perfusion, Increased urea load
Phosphate (PO_4^-)	<ul style="list-style-type: none"> 1.8–2.6 mEq/L 	Hyperparathyroidism, Diuresis, Malabsorption/malnutrition, Carbohydrate loading, Antacid abuse	Hyperparathyroidism, Renal failure, Increased growth hormone, Vitamin D intoxication

- BUN
- Creatinine
- BUN/creatinine ratio
- Na⁺
- K⁺
- CL⁻
- HCO₃⁻
- Glucose

Interpretation of Lab Values and Basic Diagnostic Tests

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

- 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

- Cholesterol
 - Normal (male and female)
 - Desirable: <200 mg/dL
 - Borderline high: 200–239 mg/dL
 - High: \geq 240 mg/dL
- Triglycerides
 - Normal (male and female)
 - Desirable: <150 mg/dL
 - Borderline high: 150–190 mg/dL
 - High: 200–499 mg/dL
 - Very high: \geq 500 mg/dL

- HDL
 - Normal
 - Positive Cardiac Risk Factor
 - HDL <35 mg/dL
 - Total cholesterol to HDL ratio
 - Men <5.0
 - Women <4.5
 - Negative Cardiac Risk Factor
 - HDL <60 mg/dL
- LDL
 - Normal
 - 160 mg/dL (male and female)
- VLDL
 - Normal
 - 10–31 mg/dL (male and female)

Interpretation of Lab Values and Basic Diagnostic Tests

CARDIAC ENZYMES AND MARKERS

- CK
 - Measures creatinine kinase
 - Normal
 - Men: 60–100 U/L
 - Women: 40–150 U/L
- 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

- LDH
 - Measures lactase dehydrogenase
 - Normal
 - Adult: 40–90 U/L
- Myoglobin
 - Measures myoglobin
 - Normal (male and female)
 - 50–120 Ég/dL

- Troponin
 - Measures troponin
 - Normal (male and female)
 - Troponin I
 - <0.6 ng/mL
 - >1.5 ng/mL (MI)
 - Troponin T
 - >0.1–0.2 ng/mL (MI)
- High levels
 - Myocardial necrosis
- Low levels
 - No clinical significance

- Amylase
 - Measures amylase
 - Normal value (male and female)
 - 53–123 U/L
- Lipase
 - Measures lipase
 - Normal value (male and female)
 - 3–19 U/L

Interpretation of Lab Values and Basic Diagnostic Tests

SEROLOGICAL TESTING

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

- A screening test for:
 - Urinary tract infections
 - Kidney disorders
 - Liver problems
 - Diabetes
- Three methods of urinalysis:
 - Visual
 - Chemical
 - Microscopic

- Two variables:
 - Colour
 - Clarity



- Qualitative- test strip/bottle
- Quantative – test strip/analyzer
- Tests for:
 - Specific gravity blood
 - Leukocyte esterase pH
 - Protein Nitrite
 - Ketones bilirubin



pH

- Measures hydrogen ion concentration
 - Acidity of urine
- Normal value (male and female)
 - 5–9
 - Mean = 6

Specific Gravity

- Measures urine concentration
- Normal value
 - Adult: 1.001–1.035
 - Child: 1.001–1.018

Protein

- Measures protein in urine
- Normal value (male and female)
 - Negative

Sugar

- Measures sugars in urine
- Normal value (male and female)
 - Negative

Ketones

- Measures ketones in urine
- Normal value (male and female)
 - Negative

Nitrites

- Measures nitrites in urine
- Normal value (male and female)
 - Negative

Leukocyte Esterase and Bilirubin

Leukocyte Esterase

- Measures leukocyte esterase in urine
- Normal value (male and female)
 - Negative

Bilirubin

- Measures bilirubin in urine
- Normal value (male and female)
 - Negative

- Measures WBCs in urine
- Normal value (male and female)
 - < 4–5 per HPF
- Measures RBCs in urine
- Normal value (male and female)
 - < 2–3 per HPF

- Usually used if abnormal findings
- Sample is centrifuged
- Concentrates settle at bottom.
- Microscope slide prepared and examined under microscope



Interpretation of Lab Values and Basic Diagnostic Tests

TOXICOLOGY

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

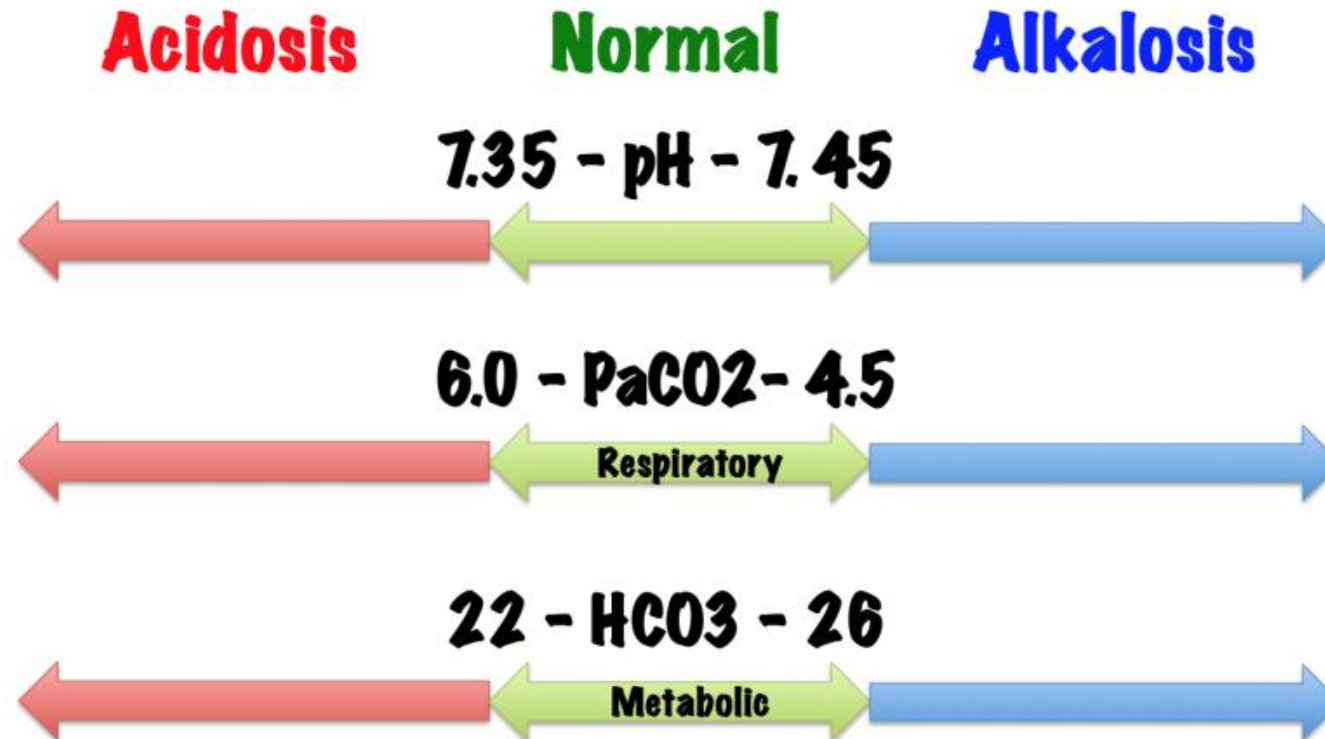
- Tests also used to determine serum levels of medications
 - Identify different levels:
 - Subtherapeutic
 - Therapeutic
 - Toxic

Interpretation of Lab Values and Basic Diagnostic Tests

ARTERIAL BLOOD GASES

- Aids in establishing a diagnosis
- Helps guide treatment plan
- Aids in ventilator management
- Improvement in acid/base management allows for optimal function of medications
- Acid/base status may alter electrolyte levels critical to patient status/care
- Provides clues about clinically unrecognized disorders
- May indicate what treatments are needed
- Helps assess progress of illness or therapy

- pH 7.40
- PCO_2 40 mmHg
- $[\text{HCO}_3]$ 24 mM
- Anion Gap = 12 - 15



Acidemia

- Blood pH < 7.35
- Acidosis: a physiologic process that, occurring alone, tends to cause acidemia
 - e.g.: metabolic acidosis from increased ketoacid production in DKA
 - If the patient also has an alkalosis at the same time, the resulting blood pH may be low, normal or high

Alkalemia

- Blood pH > 7.45
- Alkalosis: a primary physiologic process that, occurring alone, tends to cause alkalemia
 - i.e.: respiratory alkalosis from hyperventilation
 - If the patient also has an acidosis at the same time, the resulting blood pH may be high, normal or low.

Is there a problem?

What is the problem?

What is to blame?

