FORMULAE AND NORMAL VALUES

I. VITAL SIGNS

A. Temperature
1. Oral: 36.5 – 37.5 °C (97.7 – 99.5 °F)
2. Axillary: 0.3 to 0.4 °C lower
3. Rectal: 0.5 to 0.7 °C higher
4. Tympanic: 0.2 to 0.3 °C lower

B. Pulse Rate
1. Adult: 60-100 beats/min
2. Child: 80-120 beats/min
3. Infant: 100-140 beats/min
4. Neonate: 120-160 beats/min

C. Respiratory Rate:
1. Adult: 10-20 breaths/min
2. Child: 18-30 breaths/min
3. Newborn: 20-40 breaths/min
4. Neonate: 30-60 breaths/min

D. Blood Pressure
1. Adult:
   a. Normal: 90-120 mm Hg Systolic, 60-80 mm Hg Diastolic
   b. Prehypertension: 120-139 mm Hg Systolic, 80-89 mm Hg Diastolic
2. Child: 89-121 mm Hg Systolic, 48-66 mm Hg Diastolic
3. Newborn: 64-96 mm Hg Systolic, 30-62 mm Hg Diastolic
4. Neonate
   a. Weight dependent
      i. 750 g: 34-54 mm Hg Systolic, 14-34 mm Hg Diastolic
      ii. 1000 g: 39-59 mm Hg Systolic, 16-36 mm Hg Diastolic
      iii. 1500 g: 40-61 mm Hg Systolic, 19-39 mm Hg Diastolic
      iv. 3000 g: 51-72 mm Hg Systolic, 27-46 mm Hg Diastolic

E. Pulse Oximetry
1. 97% (accuracy of ± 2-3% depending on sensor & site)

II. CHEMISTRY/PHYSICS

A. Solubility Coefficients
1. Oxygen:
   a. 0.023 mL/1 mL of blood/760 mm Hg/37 C
   b. 0.003 mL/100 mL of blood/1 mm Hg/37 C
- Carbon Dioxide: 0.510 mL/1mL of blood/760 mm Hg/37

B. $$\textbf{\textit{Grams}\ of desatruated Hemoglobin} = \frac{\textbf{\textit{Hb}} \times (\mathbf{1} - \textbf{\textit{SaO}}_{\mathbf{2}}) + (\mathbf{1} - \textbf{\textit{S}}\bar{\textbf{\textit{v}}}\textbf{\textit{O}}_{\mathbf{2}})}{\mathbf{2}}$$
1. 5 gms% of desaturated hemoglobin is needed for cyanosis to be seen

C. $$\textbf{Density} = \frac{\textbf{GMW}}{\textbf{22.4L}}$$

D. Relative Humidity: $$\textbf{\textit{RH}}\% = \frac{\textbf{\textit{Content}}}{\textbf{\textit{Capacity}}} \times \mathbf{100}$$

E. Universal Formula: #mg = 10 x #mL x #%

F. $$\frac{\text{Dosage on Hand (mg)}}{\text{Volume on Hand (mL)}} = \frac{\text{Dosage Desired (mg)}}{\text{Volume Desired (mL)}}$$

G. Continuous Drug Calculation
1. CONCENTRATION = DOSAGE x OUTPUT
2. TOTAL VOLUME = RX LENGTH x OUTPUT
3. DRUG DOSAGE = DRUG CONCENTRATION x TOTAL VOLUME
4. DRUG VOLUME = DRUG DOSAGE (mg)/DRUG CONCENTRATION ON HAND
5. DILUENT VOLUME = TOTAL VOLUME – VOLUME OF DRUG

H. Dilution Problems
- $V_1 \times C_1 = V_2 \times C_2$

o 1 mm Hg = 1.36 cm H_2O
760 mm Hg = 1034 cm H_2O
760 mm Hg = 14.7 psi

III. <u>OXYGENATION MEASUREMENTS</u>

A. CaO_2 = (1.34 x SaO_2% x Hb) + (PaO_2 x .003)
1. Normal Value: 18-20 vol%
2. **** Vol% means mL of Oxygen carried in 100 mL of blood**

B. $C\bar{v}O_2$ = (1.34 x $S\bar{v}O_2$% x Hb) + ($P\bar{v}O_2$ x .003)
1. Normal Value: 12-15 vol%

C. $C\bar{c}O_2$ = (1.34 x Hb x 1) + (PAO_2 x .003)
1. Normal Value: 23 vol%

D. $C(a-\bar{v})O_2 = CaO_2 - C\bar{v}O_2$
1. Normal Value: 4-6 vol%

E. PAO_2 = [(PB - 47 mm Hg) x FiO_2] - ($PaCO_2$/RQ)
1. Normal Value: 100 - 104 mm Hg on 21%
2. 600 mm Hg on 100%

F. A-aDO_2 = PAO_2 - PaO_2
1. ****The A-a gradient is normal in hypoxemia caused by pure hypoventilation or high altitude**
2. Normal Value:
   a. Room air (21 %): 5-20 mm Hg
   b. 100% Oxygen: 25 – 65 mm Hg

G. a/A ratio = PaO_2/PAO_2
1. Normal Value: Greater than 75% (on any FiO_2)

H. PaO_2/FiO_2
1. Normal: 400 - 500
2. Less than 200 = ARDS
3. 200 – 300 = ALI

o **Classic Shunt** $\left(\frac{Q_s}{Q_t}\right) = \frac{C\bar{c}O_2 - CaO_2}{C\bar{c}O_2 - CvO_2}$

- $C\$\ O_2$ = (Hb x 1.34)+(PAO_2x .003)

4. ****Patient does not respond to O2 therapy, Treatment Is CPAP/EPAP/PEEP**
5. Normal Value: 2-5%

I. **Oxygen Index** $= \frac{\textbf{Mean airway pressure (MAP) x FiO2 x 100}}{PaO_2}$

1. 25 indicates a 50% mortality
2. 40 indicates a 80% mortality

J. Remember: when drawing an ABG on <u>21% (room air)</u>, at normal PB of 760 mm Hg, the $PaCO_2$ + PaO_2 cannot exceed 140 torr. If this is present, assume an error (i.e. air in sample or patient on oxygen therapy).

K. $\frac{KnownFiO_2}{KnownPaO_2} = \frac{DesiredFiO_2}{DesiredPaO_2}$

L. FiO_2 x 5 ≈ PaO_2

IV. <u>VENTILATION PARAMETERS</u>

A. Normal Spontaneous Tidal Volume: 5-8 mL/kg of Ideal Body Weight
1. Minute Ventilation ($\dot{V}_E$) = V_t (L) x f
2. Adult
   a. Normal: 5 – 10 L/min
3. Neonate
   a. 200-300 mL/kg/min

B. Alveolar Minute Ventilation
1. ($\dot{V}_A$) = (V_t - V_d) x f
   or
- ($\dot{V}_A$) = $\dot{V}_E - \dot{V}_D$

2. Normal: 4 - 5 L/min

C. $\frac{\dot{V}}{\dot{Q}}\ ratio = \frac{\textbf{Alveolar Ventilation } (\dot{V}_A)}{\textbf{Cardiac Output } (\dot{Q}_t)}$
1. Normal: 0.8

D. $$\frac{V_d}{V_t}\ ratio = \frac{PaCO_2 - P_{\bar{E}}CO_2}{PaCO_2}$$

1. $P_{\bar{E}}CO_2$ is mean Carbon Dioxide concentration collected in Douglas bag and analyzed.
2. **** Increased in deadspace disease**
3. Normal Value: 25 – 40%
4. Normal Value for $P_{\bar{E}}CO_2$ = 35-43 torr, 4.6-5.6%
5. $PaCO_2$ – $P_{ET}CO_2$ = 1 to 6 mm Hg. If greater, suspect increased deadspace.

E. $$V_d = \frac{PaCO_2 - P_{\bar{E}}CO_2}{PaCO_2} \times V_t$$

- Normal Value: 1cc/lb of ideal body weight for Anatomic Deadspace

F. $$\textbf{Rapid/Shallow Breathing Index } (f/V_t) = \frac{\textbf{f (frequency)}}{V_t\,(liters)}$$

- Normal Value: Less than 105

G. $$Compliance = \frac{\textbf{Tidal Volume (L)}}{\textbf{Transpulmonary Pressure (cm } H_2O\textbf{)}}$$

1. Normal Lung Compliance: 0.2 L/cm H_2O
2. Normal Thoracic Compliance: 0.2 L/cm H_2O
3. Normal Total Lung Compliance: 0.1 L/cm H_2O

H. $$\textbf{Static Compliance} = \frac{\textbf{Tidal Volume}}{\textbf{(Plateau Pressure - TOTAL PEEP)}}$$

1. **Plateau, Static, Alveolar Pressure are all the same**
1. Normal: 60 – 100 mL/cm H_2O or 0.06 to 0.1 L/cmH_2O
2. TOTAL PEEP = (Applied PEEP + Auto PEEP)

I. $$\textbf{Dynamic Compliance} = \frac{\textbf{Tidal Volume}}{\textbf{(Peak Pressure - TOTAL PEEP)}}$$

1. Normal: 30 – 40 mL/cm H_2O
2. TOTAL PEEP = (Applied PEEP + Auto PEEP)

J. One Time Constant = C x R_{aw} (3 time constants needed to exhale 95% of Vt)

K. $$\textbf{Airway Resistance } (R_{aw}) = \frac{\textbf{Peak Pressure - Plateau Pressure}}{\textbf{Flowrate in L/min}}\ \textbf{x 60}$$

- Normal Value: 0.5 – 2.5 cm H_20/L/sec
  - Less than 5 cm H_20/L/sec is acceptable.

o $$\textbf{Square Flowrate (L/min)} = \frac{\textbf{Tidal Volume (L)}}{\textbf{Inspiratory Time (sec)}}\ \textbf{x 60}$$

- Normal Adult spontaneous flow rate is 24 to 30 liters/minute

L. Ideal Body Weight

1. Males: IBW in lbs = (height inches – 60) x 6 + 106
2. Females: IBW in lbs = (height inches – 60) x 5 + 105

M. $$\textbf{Desired Change } (\mathbf{f, V_t, \dot{V}_E}) = \frac{\textbf{Known } \mathbf{PaCO_2} \times \textbf{Known Parameter } (\mathbf{f, V_t, \dot{V}_E})}{\textbf{Desired } \mathbf{PaCO_2}}$$

N. Henderson-Hasselbalch Equation $$\boldsymbol{pH} = \boldsymbol{pK} + \log \frac{\boldsymbol{HCO_3^-}}{(\boldsymbol{PaCO_2} \times \mathbf{.03})}$$

O. Total CO_2 = HCO3 + ($PaCO_2$ x 0.03)
   1. Normal: 25.2 mEq/L

P. $$\boldsymbol{PaCO_2} = \frac{\boldsymbol{\dot{V}CO_2} \times \mathbf{.863}}{\boldsymbol{\dot{V}_A}}$$
   1. Normal: 35- 45 mm Hg

Q. $$\textbf{Total Cycle Time (TCT)} = \frac{\textbf{60 seconds}}{\mathbf{f}}$$

R. $$\textbf{Inspiratory Time } (\mathbf{T_I}) = \frac{\textbf{Total Cycle Time (TCT)}}{\textbf{(Sum of I : E ratio)}}$$

S. Expiratory Time (T_E) = TCT - TI

V. <u>PULMONARY FUNCTION VALUES</u> (70 kg, 72 inch, 21 year-old male)
- Tidal Volume (Vt): 500 mL (5-8 mL/kg of Ideal Body Weight)
- Inspiratory Reserve Volume (IRV): 3,100 mL
- Expiratory Reserve Volume (ERV): 1,200 mL
- Residual Volume (RV): 1,200 mL
- Inspiratory Capacity (IC): 3,600 mL
- Functional Residual Capacity (FRC): 2,400 mL
- Total Lung Capacity (TLC): 6,000 mL
- Vital Capacity (FVC): 4,800 mL (60 to 75 mL/kg IBW)
- Predicteds: Most common <u>Morris</u>, Crapo, Knudson
  - Actual values should be between 80 and 120% of predicted value.
  - The exception is the $FEV_{1.0}$/FVC % which should be greater than 70%.
- Forced Vital Capacity = Slow Vital Capacity with normal lungs.
- Predicted Formulae (Regression Formulae) can be found in Egan, pages 417-418

A. MIP: -60 to -120 cmH_2O

B. MEP: 60 to 120 cmH_2O

C. Measuring the Pre- and Post-bronchodilator FEV_1 or Peak Flow can assess the effectiveness of a bronchodilator. The formula is

$$\%\boldsymbol{Change} = \frac{\boldsymbol{POST} - \boldsymbol{PRE}}{\boldsymbol{PRE}} \times \mathbf{100}\%$$

   1. A % change in the FEV_1 of 12% **and** 200 mL or greater is considered a significant change.

D. Resting Energy Expenditure (REE)
   1. Calories needed at rest
   2. Also known as the Basal Metabolic Rate (BR)

E. Respiratory Quotient (RQ)
1. The energy required at the cellular level
2. Difficult to measure
3. Extrapolated from the RER
4. Depends on substrate utilization
   a. Combination = 0.8
   b. Fat = 0.7
   c. Carbohydrate = 1.0
   d. Protein = 0.85

F. Respiratory Exchange Ratio
1. Measured at the mouth
2. Estimate of RQ
3. $\textbf{Respiratory Exchange Ratio} = \frac{\dot{V}CO_2}{\dot{V}O_2}$

VI. HEMODYNAMIC VALUES

o Oxygen Delivery = CaO2 x # $_t$ x 10
1. Normal Value: 900 – 1000 mL/min

B. $\textbf{Respiratory Quotient} = \frac{\textbf{CO}_2\textbf{Production}}{\textbf{O}_2\textbf{Consumption}}$

1. Normal: $\frac{200\,ml/\min}{250\,ml/\min} = 0.8$

C. Cardiac Output = SV x HR
1. Cardiac Output: 4-8 L/min

D. $HR = \frac{CO(ml/\min)}{SV(ml/beat)}$

E. Blood Pressure (BP) = CO x SVR

o Fick Equation: $\textbf{Cardiac Output}\left(\dot{Q}_t\right) = \frac{\dot{V}_{O_2}}{C(a-v)O_2 \times 10}$

o Fick Equation: $\textbf{Oxygen Consumption}\left(\dot{V}_{O_2}\right) = CO \times C(a-v)O_2 \times 10$

1. Normal: 250 mL/min

F. $\textbf{Oxygen Extraction Ratio} = \frac{C(a-v)O_2}{CaO_2}$

1. Normal: 25%

G. $MAP = \frac{[(2 \times diastolic) + systolic]}{3}$

1. Normal: 80 – 100 mm Hg

H. Heart Pressures
1. Left Ventricle: 120/0 mm Hg
2. Arterial Blood Pressure: 120/80 mm Hg
3. Mean Arterial Pressure: 93 mm Hg (80 - 100)
4. Arterioles: 30 mm Hg
5. Capillaries: 20 mm Hg
6. Veins: 10 mm Hg
7. Right Atrium (CVP): 2-6 mm Hg (4-12 cm H_20)
8. Right Ventricle 25/0 mm Hg
9. Pulmonary Artery 25/8 mm Hg
10. Mean Pulmonary Artery Pressure: 14-15 mm Hg (10-20 mm Hg)
11. Pulmonary Capillary Wedge Pressure (PCWP): 4-12 mm Hg
12. Pulmonary capillaries 12 mm Hg
13. Pulmonary veins 8-10 mm Hg
14. Left Atrium 5 mm Hg
15. Left Ventricle - 120/0

I. Pulse Pressure = Systolic Blood Pressure – Diastolic Blood Pressure
1. Normal: 30 – 50 mm Hg

J. $$\textbf{Stroke Volume (mL)} = \frac{\textbf{Cardiac Output (mL/min)}}{\textbf{Heart Rate (min)}}$$
1. Normal: 60 – 130 mL/beat

K. $$\textbf{Stroke Volume Index} = \frac{\textbf{Stroke Volume}}{\textbf{Body Surface Area)}}$$
1. Normal: 30 – 65 mL/beat/m^2

L. $$\textbf{Cardiac Index} = \frac{\textbf{Cardiac Output}}{\textbf{Body Surface Area)}}$$
1. Normal: 2.5 – 3.5 L/min/m^2

M. $$\textbf{Ejection Fraction} = \frac{\textbf{Stroke Volume}}{\textbf{End Diastolic Volume}}$$
1. Normal: 60-75%

N. $$\textbf{Systemic vascular resistance} = \frac{\textbf{MAP - CVP}}{\textbf{Cardiac Output}}$$
1. ** To convert to dynes, multiple mm Hg/L/min x 80
2. Normal: 15 – 20 mm Hg/L/min
3. 1200 - 1600 dynes/sec/cm5

O. $$\textbf{Pulmonary vascular resistance} = \frac{\textbf{MPAP - PCWP}}{\textbf{Cardiac Output}}$$
1. ** To convert to dynes, multiple mm Hg/L/min x 80
2. Normal: 1.5 – 3.0 mm Hg/L/min
3. 120 – 240 dynes/sec/cm5

P. **Systemic vascular resistance index** $= \frac{\textbf{SVR}}{\textbf{BSA}}$

1. Normal: 1970 – 2400 dynes/sec/cm^5/m^2

Q. **Pulmonary vascular resistance index** $= \frac{\textbf{PVR}}{\textbf{BSA}}$

1. Normal: 225 – 315 dynes/sec/cm^5/m^2

VII. CONSERVATIVE THERAPY

o 1 cubic foot of liquid oxygen = 860 cubic feet of gaseous oxygen
1 liter of liquid oxygen = 860 liters of gaseous oxygen
1 pound of liquid = 344 liters of gas

A. **Duration of cylinder flow (minutes)** $= \frac{\textbf{(pressure in cylinder 500) x cylinder factor}}{\textbf{liter flow}}$

1. Normal Cylinder Factor:
   a. 0.28 for E cylinder
   b. 3.14 for H cylinder

2. **Cylinder Factor** $= \frac{\textbf{(cu/ft in full cylinder x 28.3)}}{\textbf{Pressure of full cylinder}}$

B. Total Liter Flow = sum of air:O_2 ratio x O_2 liter flow

C. If you are using an oxygen flowmeter to deliver a He/O_2 mixture, the factor is:
1. 80/20 mixture: 1.8 x flowrate
2. 70/30 mixture: 1.6 x flowrate
3. Example: You are using an oxygen flowmeter to deliver a 80/20 He/O_2 mixture. The flowrate is set at 10 L/min. What is the actual flow to the patient? 10 x 1.8 = 18 LPM
4. Example: You are using an oxygen flowmeter to deliver a 70/30 He/O_2 mixture. The flowrate is set at 8 L/min. What is the actual flowrate? 8 x 1.6 = 12.8 L/min

D. **FiO2** $= \frac{\textbf{(Air Flowrate x 0.21)} + \textbf{Oxygen Flowrate}}{\textbf{Total Flowrate}}$

E. Liquid Calclation

1. **Duration in minutes** $= \frac{\textbf{Liquid Capacity (L) x 860 x gauge reading}}{\textbf{Flow}}$

2. **Duration in minutes** $= \frac{\textbf{Pounds of Liquid x 344}}{\textbf{Flow}}$

VIII. LABORATORY VALUES

A. **CHEMISTRY**

LAB VALUE	NORMAL VALUE	PURPOSE	ABNORMAL (Results from or results in)
Sodium (Na+)	135 – 145 mEq/L	• Healthy electrolyte concentrations are essential for proper physiologic function of the body. • The RCP is interested in the electrolyte panel because the results may be responsible for blood acid-base abnormalities, irregular heart rhythms or weak muscles of breathing. • Electrolytes are closely associated with fluid levels and kidney function • **Sodium** is the major extracellular cation controlled by the kidneys. • Controlled by and retained by the kidney in exchange for K+ • Major extracellular cation	• General symptoms of electrolyte imbalance: muscle weakness, soreness, nausea and mental changes such as lethargy, dizziness and drowsiness. • **Low value** – Hyponatremia results from loss of fluids (vomiting, diarrhea, diuretics) or fluid gain (CHF, IV) • **High value** – Hypernatremia results from dehydration or excess IV administration

LAB VALUE	NORMAL VALUE	PURPOSE	ABNORMAL (Results from or results in)
Potassium (K+)	3.5 – 5.0 mEq/L	• Major intracellular cation • Important in acid-base balance	• **Low value** – Hypokalemia results in metabolic alkalosis and flattened T waves on EKG. Loss can be caused by excessive excretion (diuresis) or vomiting. • **High value** – Hyperkalemia results in spiked T wave on EKG and metabolic acidosis. It can be caused by renal failure
Chloride (Cl-)	85 – 100 mEq/L	• Major extracellular anion	• **Low Value** – Hypochloremia results in metabolic alkalosis. • **High value** – Hyperchloremia results in metabolic acidosis.
Bicarbonate (HCO3-) or Total CO2 content (TCO2 cont.)	HCO2- = 22 – 26 mEq/L TCO2 = 23.2 – 26.2 mEq/L	Most of the CO2 in the blood is carried as HCO3- so changes in TCO2 reflect changes in blood base.	• **Low value** – results in metabolic acidosis • **High value** – results in metabolic alkalosis • (Changes in opposite direction as PaCO2)
Calcium	Normal range: 8.5-10.3 mg/dL		• **High value** in hyperparathyroidism, bone metastases, myeloma, sarcoidosis, hyperthyroidism • **Low value** in Hypoparathyroidism, renal failure, malabsorption, pancreatitis, hypoalbuminemia, vitamin D deficiency, overhydration

LAB VALUE	NORMAL VALUE	PURPOSE	ABNORMAL (Results from or results in)
Blood urea nitrogen (BUN)	8 – 25 mg/dL	Evaluates kidney function and ability to excrete waste products of metabolism (protein)	• **High value** – seen in renal failure
Magnesium	0.6-1.0mmol/L		• **High value** in renal disease, excess Mg intake • **Low value** with diarrhea, malabsorption, diuretics
Serum Creatinine (Cr)	0.7 – 1.3 mg/dL	• Evaluates kidney function and ability to excrete waste products of metabolism (protein) • More specific for kidney failure than BUN	• **High value** – seen in renal failure
Total protein	6.2 – 8.2 g/dL	• Tests liver/kidney function	• **Low value** - seen in patients with poor nutrition, liver disease, diarrhea, and burns • **High value** - is seen in patients with lupus, chronic infections, alcoholism, leukemia and TB
Albumin	3.6 – 5.0 g/dL	• Major constituent of serum protein • Test for liver/kidney function	• **High value** seen in shock, dehydration, or multiple myeloma • **Low value** seen in patients with poor diets, diarrhea, fever, infections, 3rd degree burns, and edema
Glucose (fasting)	65 – 115 mg/dL	• Test of diet, pancreatic function, insulin: glucose balance…	• Hyperglycemia = increased glucose levels (as seen in diabetes) • Hypoglycemia = decreased glucose levels

LAB VALUE	NORMAL VALUE	PURPOSE	ABNORMAL (Results from or results in)
Immunoglobulins IgG, IgA, IgM, IgE, IgD	IgG 700 - 1450 mg/dL IgA 70 – 370 mg/dL IgM 30 –210 mg/dL IgE IgD	• IgG = antibody activity • IgA = protects the mucous membranes in respiratory and Gastrointestinal tract • IgM = appears after antigenic stimulation	• **IgE** = has antibody activity for hypersensitivity reactions • **High value** seen in asthma, anaphylactic shock, hay fever and atopic skin disease. • **IgD** = Its function is unknown. • **High value** seen in chronic infections, connective tissue disorder, and liver disease • **Low value** seen with heredity and some acquired deficiency syndromes
Cholesterol	Normal range: 120 – 240 mg/dL	• >240 mg/ dL (high) • 200 – 239 mg/dL (borderline) • 120 – 180 mg/dL (good)	• **High value** of cholesterol is common in patients with atherosclerosis, diabetes, hypothyroidism, or pregnant • **Low value** cholesterol is seen in patients with depression, malnutrition, anemia, liver insufficiency, and infections
High and low-density lipoproteins	HDL = high density lipoprotein 35 – 135mg/dL LDL = low density lipoproteins 62 – 130mg/dL	• HDL = GOOD cholesterol • LDL = BAD cholesterol	• **High value** of HDL is an indication of a healthy metabolic system if no intoxication or liver disease is present. • **High value** in LDL is associated with arterial atherosclerosis

LAB VALUE	NORMAL VALUE	PURPOSE	ABNORMAL (Results from or results in)
Theophylline level	10-20 mg/L	• Measures the amount of xanthines in the blood	• **Out of range low** is sub therapeutic • **Out of range high** is toxic and results in side effects.
Bilirubin (total)	0.3 – 1.1mg/dL	• Test for liver function	• **High levels** - in patients with liver disease, mononucleosis, hemolytic anemia • **Low levels** - in patients with insufficient liver and associated with excessive fat consumption
Albumin	3.6 – 5.0 g/dL	• Major constituent of serum protein • Test for liver/kidney function	• **High value** seen in shock, dehydration, or multiple myeloma • **Low value** seen in patients with poor diets, diarrhea, fever, infections, 3rd degree burns, and edema
Sweat chloride	15mEq/L – 50mEq/L	• Test used to help aid in the diagnosis of cystic fibrosis	• >60 mEq/L = positive test for infants and children • >80 mEq/L = positive test for adults
Theophylline level	10-20 mg/L	• Measures the amount of xanthines in the blood	• **Out of range low** is sub therapeutic • **Out of range high** is toxic and results in side effects.
Serum enzymes (AST, ALT, ALP, LDH, CK)	AST = 8 - 20 U/L	• Evaluating the enzymes gives clues as to which body system is causing the patient's symptoms.	• Disease affecting a certain organ causes a release of excessive amounts of the enzymes stored in that organ into the circulating blood.

F. **HEMATOLOGY**

LAB VALUE	NORMAL VALUE	PURPOSE	ABNORMAL (Results from or results in)
Red blood cell count	4 - 6 mill/cu mm	• RBC carries Hb & oxygen to the tissues.	• **High levels -** RBC (polycythemia) with chronic tissue hypoxia • **Low levels** - RBC (anemia) with blood loss.
Erythrocyte indices: Mean cell volume (MCV) Mean cell hemoglobin (MCH) Mean cell hemoglobin Concentration (MCHC)	MCV 80-105/cu. micron MCH 27-31 MCHC 32-36%	• May help diagnose a specific type of anemia	
Neutrophils	4% of WBC 60% of WBC	• Most common WBC. The major line of defense against bacterial infections. o **Bands** - Immature cells o **Segments** - Mature cells	• **Bands increase** with bacterial infection • **Segments decrease** with bacterial infection
Eosinophils	2% of WBC	• Associated with asthma.	• **High values** with allergic reactions and produce a "yellow" sputum
Monocytes	3% of WBC	• Associated with tuberculosis	• **High values** of monocytes are seen in patients with leukemia, infections, and carcinomas
Lymphocytes	30% of WBC	• B cells = formed in bone marrow • T cells = formed in the thymus gland	• **High values** may indicate an active viral infection such as measles, chicken pox, or mononucleosis

LAB VALUE	NORMAL VALUE	PURPOSE	ABNORMAL (Results from or results in)
Basophils	1% of WBC	• Basophil activity is not fully understood – but is known to carry histamine, heparin, and serotonin	• **High values** of basophils are associated with allergic reactions
Reticulocyte Count	0.5 – 2%	• Help distinguish between hypoproliferative and hyperproliferated anemias	• **Low values** = hypoplastic anemia or ineffective erythropoiesis • **High values** = hemolysis or blood loss
Platelet ***RCP to review prior to ABG puncture***	150,000 - 400,000/mm 3	• Important for blood coagulation by forming blood clots.	• **Low values** - are associated with decreased bone marrow function
Clotting time	Up to 6 minutes	• Used to evaluate pre-op bleeding risk, bleeding signs & symptoms, disseminated intravascular coagulation (DIC) or to monitor anticoagulation therapy	• Clotting time is increased when patients are taking anticoagulants and thrombolytics
Activated partial thromboplastin time (APTT) ***RCP to review prior to ABG puncture***	25 – 36 seconds	• Quantify the clotting mechanisms of the body	•

LAB VALUE	NORMAL VALUE	PURPOSE	ABNORMAL (Results from or results in)
Activated prothombin time (APTT)	24 - 32 seconds	• Measures the length of time required for plasma to form a fibrin clot • Used to monitor Heparin therapy	• **High value** - > 100 seconds may cause spontaneous bleeding.
Prothombin time (PT)	12 - 15 seconds	• RCP to review prior to ABG puncture. • Used to monitor Warfarin (Coumadin) therapy.	• **High value** - >30 seconds may cause spontaneous bleeding

. **MICROBIOLOGY**

LAB VALUE	NORMAL VALUE	PURPOSE	ABNORMAL (Results from or results in)
Normal Flora		• Normal Oral organisms	
Sputum gram stain (Can be done on blood, sputum, pleural fluid)	Gram positive = purple under microscope Gram negative = pink under microscope	• Useful in determining the category of organism responsible for the patient's infection. (gram + or gram -)	• Gram (-): Klebsiella o Pseudomonas o Aeruginosa o Hameophilus o Influenzae • Gram (+): Streptococcous o Staphlococcous
Sputum culture (Can be done on blood, sputum, pleural fluid)		• Useful in determining the actual organism responsible for the patient's infection.	
Sensitivity (Can be done on blood, sputum, pleural fluid)		• Useful in determining which antibiotics or other anti-infective will be most useful in treating an infection.	

LAB VALUE	NORMAL VALUE	PURPOSE	ABNORMAL (Results from or results in)
Cytology	Satisfactory specimens contain less than 25 leukocytes and less than 10 squamous epithelial cells per high powered field.	• Study of cells brought up from a deep lung specimen.	• Abnormal findings include pathogens more abundant than found in normal flora or non-flora pathogens or abnormal cells from malignant tumors responsible for producing the majority of primary lung cancers.
Acid fast stain (sputum) (may take 6 - 8 weeks to complete)	Negative for M.tuberculosis	• Commonly used to confirm the diagnosis of infection with M. tuberculosis	• Positive for M. tuberculosis
Fungus	Negative for fungus	• Used to confirm the diagnosis of a fungal disease such as Histoplasmosis or Coccidioido-mycosis	• Presence of fungal spores

. **URINALYSIS**

LAB VALUE	NORMAL VALUE	PURPOSE	ABNORMAL (Results from or results in)
Specific gravity	1.003 – 1.030	• Urinalysis reflects the metabolic status of a patient and is a screening test for kidney disease. • May indicate urinary infection before blood culture results	• Urine becomes darker and its odor becomes stronger as the specific gravity increases • Usually higher with the first urine output of the day
pH	4.5 – 8.0		• Greatly affected by diet and medications • pH influences the appearance of urine and the composition of crystals
Glucose concentration	None		• Stress, pregnancy or a high carbohydrate diet may cause an appearance of glucose

LAB VALUE	NORMAL VALUE	PURPOSE	ABNORMAL (Results from or results in)
Protein content	None		• Protein can appear in a benign condition known as orthostatic proteinuria. • Proteinuria suggests renal disease, or renal failure
Ketones	Negative		• Usually seen in diabetic patients where in the absence of glucose, cells metabolize triglyceride, an alternate energy supply. • Ketone bodies are the end products of incomplete fat metabolism which accumulate in plasma and are excreted in urine
Blood	None/Negative		• May be normal if seen after surgery
Bilirubin	Negative	• Evaluates liver function	• Bilirubin is increased in hepatocellular damage Ex. Hepatitis • May accompany jaundice and hemolytic anemia
Urobilinogen	Males: .3 –2.1 Females: 0.1 – 1.1 (in a 2 hour period)		• Out of range in hepatobiliary and hemolytic disorders

. PLEURAL FLUID

LAB VALUE	NORMAL VALUE	PURPOSE	ABNORMAL (Results from or results in)
Pleural fluid amount	< 20mL of serous fluid	• Fluid specimen is used to determine the cause and nature of the pleural effusion	• Out of range
Pleural fluid color	Clear	• Assessing color will aid in the diagnosis and possibly help indicate how long the effusion has been present	• Milky = chyle • Red = bloody • Brown = old blood • Cloudy = empyema
pH	Usually slightly higher than blood pH		• A pH of 7.2 or less may occur in: systemic acidosis, TB, or a malignant disease
Protein content	3g/dl	• Tells if the effusion is a transudate or exudate.	• **Transudate** = a low protein fluid that has leaked from normal vessels • **Exudate** = a protein-rich fluid that has leaked from blood vessels with increased permeability

. SKIN TESTING

LAB VALUE	NORMAL VALUE	PURPOSE	ABNORMAL (results from or results in)
Response to purified protein derivative (PPD) TB Testing	Negative or no redness or reaction	Measures the hypersensitivity that follows exposure to tuberculoprotiens	• Check for an induration or wheal forming after 48 - 72 hours • Between 5 - 9 mm is suspicious • 10 mm or greater is considered positive for recent or past infection or disease. • This does not mean active disease is present.

. BLOOD GASES

0. ADULT BLOOD GASES

LAB VALUE	NORMAL VALUE Arterial	NORMAL VALUE Venous	PURPOSE	ABNORMAL ARTERIAL RESULTS (Results from or results in)
pH	7.35 - 7.45 No units of measure	7.32 – 7.42	• Required to maintain acceptable environment (homeostasis) for normal cellular function	• **Low value** - results from loss base (HCO_3^-) or gain of acid (CO_2 or fixed) • **High value** - results from gain of base or loss of acid
PCO_2	35 - 45 mmHg	41 - 51 mmHg	• Evaluation of the efficiency of CO_2 removal (volatile acid) through the lungs	• **Low value** result from hyperventilation • **High value** results from hypoventilation or lung disease impairing CO_2 removal
PO_2	80 - 100 mmHg	35 - 45 mmHg	• Evaluation of the lungs ability to take up oxygen into the arterial blood. • Dissolved O_2 (3% of total blood O_2) determines Hb loading.	• 79-60 mild hypoxemia • 59-40 moderate hypoxemia • <40 severe hypoxemia
HCO_3^-	22 - 26 mEq/L	24 - 30 mEq/L	• Evaluation of the efficiency HCO_3^- (base) regulation at the kidney	• Effects the pH and acid/base balance
BE	$\pm$ 2		• Evaluation of the total body buffer system balance	
HHb	Male 13 – 17 gm% Female 12 - 16 **HCT ≈ 3xHb** Male 41 – 50% Female 35 – 46%	same	• Test for the amount of Hb in the blood. Main carrier of oxygen to the tissues (97%) • Carries oxygen in the RBC at approximately 1.34 mL/gram Hb.	• **Low value** – anemia • **High value** - polycythemia

LAB VALUE	NORMAL VALUE Arterial	NORMAL VALUE Venous	PURPOSE	ABNORMAL ARTERIAL RESULTS (Results from or results in)
O_2Hb (SaO_2 or $S\bar{v}O_2$)	97 - 97%	70 - 75%	• CO-Oximeter - Actual saturation of Hb with oxygen - **fractional saturation** • ABG - **Calculated** saturation of Hb based on pH and PO_2 • Pulse Ox - Estimate of **functional saturation** or amount of Hb combined with something vs. Reduced Hb	• <89% may qualify a patient for home oxygen. • <92% may qualify a patient for O_2 in an acute care setting.
COHb	<2% normal, 5 - 10% smokers, 10-15% heavy smokers	Same	• Measurement of the % of Hb with carbon monoxide attached	• Carbon monoxide will replace oxygen on the hemoglobin and can lead to hypoxia
MetHb	Normal MetHb <2%	Same	• Measurement of the amount of Hb bound with nitrogenous waste products	• Affects loading and unloading of oxygen from Hb
CaO_2 or $C\bar{v}O_2$	18 - 20 vols%	12 - 15 vols%	• Dissolved O_2 + combined O_2 in mL/100 mL of blood • (PaO_2 x 0.003) + (Hb x 1.34 x SaO_2)	• Checks the amount of O_2 per 100ml of blood