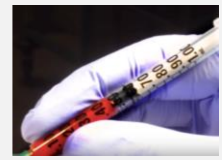
"STAYIN' ALIVE!" THE BASICS OF BLOOD GAS INTERPRETATION

1

LEARNING OBJECTIVES

1. Understand the biochemical components of the blood gas
2. Recognize the effect renal and pulmonary buffering systems on acid-base balance
3. Apply principles of the oxy-hemoglobin dissociation curve to clinical practice
4. Interpret arterial blood gases and suggest nursing care strategies to encourage acid-base homeostasis



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BLOOD GAS COMPONENTS

pH - numerical value based on hydrogen ions present (H+)/ measure of the acid-base balance of the blood.

PaCO2 - the partial pressure of carbon dioxide found in arterial blood.

PaO2 - the partial pressure of oxygen found in arterial blood.

Bicarbonate - the calculated value of the amount of bicarbonate in the blood (HCO3-).

Base excess (BE) / Base deficit (BD) - quantity of base (HCO_3^-, in mEq/L) that is above or below the normal range of buffer base. Normal value is -2 to +2 with 0 being ideal.

3

"NORMAL" BLOOD GAS VALUES

pH	7.35 - 7.45
PaCO2	35 - 45
PaO2	80 - 100
HCO3	22 - 26
SaO2	88 - 100

4

BEGIN BY LOOKING AT EACH COMPONENT SEPARATELY

Acid-Base Status

7.30 / 50 / 80 / 22.6 / 95%. / -I

pH / P_aCO_2 / P_aO_2 / HCO_3^- / O_2 sat / BD/BE

Ventilation

Oxygenation

5

OXYGENATION

- Oxygenation refers to the supply of oxygen to the tissues.
- Affected by cardiac output and oxygen content in the blood

6

OXYGEN CONTENT

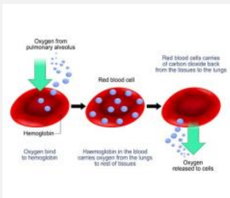


Image Credit: ClipDealer. 2020. Media-ID: A:125585543

Oxygen binds to hemoglobin in the blood (98%)

Factors that influence this bond (saturation), as well as the hemoglobin content, directly affect the amount of oxygen available to the tissues.

7

OXYHEMOGLOBIN DISSOCIATION CURVE

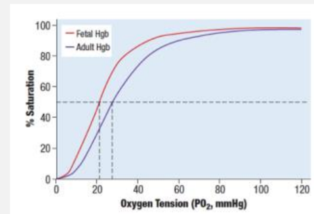


Figure 4.7 Postnatal oxygen dissociation curve.

Image Credit: Jnah & Trembath (2019)

8

FACTORS THAT AFFECT OXYGEN BINDING

- Ratio of adult (HgA) to fetal (HgF) hemoglobin
- Temperature
- PaCO2
- Concentration of 2,3-DPG
- Hydrogen ion concentration (pH)

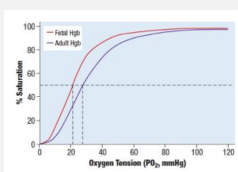


Figure 4.7 Postnatal oxygen dissociation curve.

Image Credit: Jnah & Trembath (2019)

9

RIGHT SHIFT

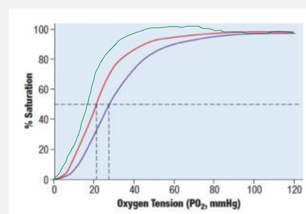


Figure 4.7 Postnatal oxygen dissociation curve.

HgB easily releases oxygen to the tissues

"HgB affinity for oxygen goes ↓

Key Principle: More oxygen (Fi02) is needed to reach the same hemoglobin % saturation level

10

LEFT SHIFT

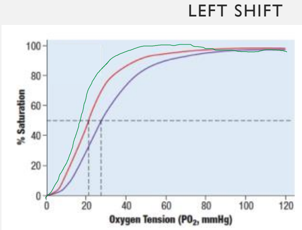
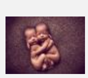


Figure 4.7 Postnatal oxygen dissociation curve.



Left Shift = HgB holds onto oxygen

"HgB affinity for oxygen goes ↑

LESS oxygen (Fi02) is needed to reach the same hemoglobin % saturation level

11

IMPORTANT CLINICAL IMPLICATION

- If an infant has a PaO2 of 45 with a pH of 7.23, you can expect the PaO2 to fall as the pH corrects.
- The % saturation may increase once the PaO2 reaches an acceptable level, but the hemoglobin molecule will not easily release oxygen to the tissues. <u>This creates hypoxia</u>.

12

ACID-BASE BALANCE

Purpose for maintaining the appropriate acid-base balance:

Maintains a stable pH
Prevents enzyme inactivation
Encourages healthy cellular function

Consequences of altered acid-base balance:

Impaired vascular tone, myocardial dysfunction, electrolyte disturbances, risk for arrhythmias and muscle weakness, impaired cellular respiration

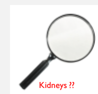
13

ACID-BASE BALANCE

The body's 2 buffering systems are:

- The **kidneys** (renal excretion of excess hydrogen ions)
- The **lungs** (pulmonary excretion of excess CO2)

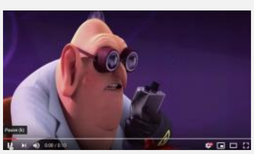
When possible, **you** want to **focus management** to the **system causing the problem.**



14

14

RENAL BUFFERING SYSTEM



Slow process… may take hours to days…

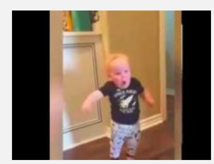
- Excrete acid by acidifying urine and reclaiming all filtered bicarbonate
- Excrete urinary ions (e.g. phosphate) which combine with H+ to form an acid that can be titrated
- Produces ammonia (may bind H+ to form ammonium ions)

15

15

PULMONARY BUFFERING SYSTEM

- Increase in carbonic acid formed when there is excess CO2, stimulates the medulla, which drives respiration
- Respiratory Rate (minute ventilation) increases or decreases (as does depth of ventilation) until an appropriate CO2 level achieved



Quick response time – often just a matter of minutes

16

BASIC PRINCIPLES

Increase in CO_2 **Acidosis**	Decrease in CO_2 **Alkalosis**
Decrease in HCO_3 **Acidosis**	Increase in HCO_3 **Alkalosis**

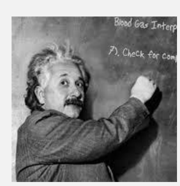
↓ **pH** ↑ **pH**

17

COMPENSATION

The body's attempt to manipulate the buffering systems is referred to as Compensation. If acidosis or alkalosis is present, the ABG might be:

Compensated,
Uncompensated, or
Partially Compensated



18

INTERPRETING BLOOD GAS COMPENSATION

- **Uncompensated**: pH is abnormal and one of the acid-base components is abnormal and one normal
- **Partially Compensated:** 2 acid-base components are abnormal in opposite directions
- **Compensated:** pH is normal and one/both of the acid-base components is abnormal

19

DETERMINING ACID-BASE BALANCE

CONDITION	PRIMARY DISTURBANCE	COMPENSATION
Metabolic Acidosis	Decreased HCO_3	Decreased $PaCO_2$
Metabolic Alkalosis	Increased HCO_3	Increased $PaCO_2$
Respiratory Acidosis	Increased $PaCO_2$	Increased HCO_3
Respiratory Alkalosis	Decreased $PaCO_2$	Decreased HCO_3

20

DIFFERENTIAL DIAGNOSIS FOR METABOLIC ACIDOSIS

Etiologies for a High-Anion-Gap Acidosis

- Lactic Acidosis (asphyxia, hypoxemia, shock, cold stress, NEC, PDA, sepsis)
- IEM (organic acidemia, galactosemia, hereditary fructose intolerance)
- Acute Renal Failure

21

DIFFERENTIAL DIAGNOSIS FOR NORMAL ANION GAP ACIDOSIS

RTA	Renal dysplasia	Obstructive uropathy	Diarrhea
Ileal or small bowel drainage	Excess acid/amino acid administration in TPN	High-protein formula	Congenital hypothyroidism

22

DIFFERENTIAL DIAGNOSIS FOR METABOLIC ALKALOSIS

High Urinary Chloride

- Bartter Syndrome
- Chloride deficiency
- Exogenous bicarbonate, acetate, or citrate
- Diuretics (early)

Low Urinary Chloride

- Acid loss (vomiting, nasogastric suctioning)
- Diuretics (late)
- Secretory diarrhea
- Correction of chronic respiratory acidosis

Low Blood Chloride

- Pyloric stenosis
- Cystic Fibrosis
- Bartter Syndrome
- Diuretic use

23

PRIMARY (UNCOMPENSATED) RESPIRATORY ACIDOSIS

- Low pH, high PCO2, normal bicarb
- Usually caused by insufficient alveolar ventilation secondary to lung disease
- Disease states associated with hypoventilation: V/Q mismatch, asphyxia, periodic breathing, apnea, upper airway obstruction, RDS, PIE, pneumonia, pneumothorax, CNS infection, hemorrhage, cardiac disease

24

PRIMARY (UNCOMPENSATED) RESPIRATORY ALKALOSIS

- High pH, low PCO2, normal bicarb
- Usually caused by hyperventilation of the alveolus leading to deficiency of carbonic acid - usually iatrogenic (i.e.: air bubble in syringe, too much PPV in the delivery room)
- Disease states associated with hyperventilation: CNS response to hypoxia, tachypnea, urea cycle disorders, maternal heroine addiction

25

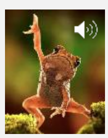
MIXED METABOLIC/RESPIRATORY ACIDOSIS

- pH low, PCO2 high, HCO3 low
- Example: severe respiratory disease with hypercapnia leading to a respiratory acidosis along with hypoxia leading to lactic acid build-up and metabolic acidosis.

26

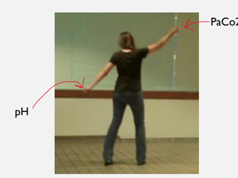
ABG INTERPRETATION DR. J'S 5 STEPS FOR SUCCESS:

1. Interpret the **pH**
2. Interpret the PaC02
3. Interpret the HC03
4. Analyze for compensation
5. Interpret Pa02



27

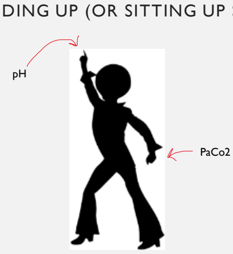
PLEASE STAND UP (OR SIT UP STRAIGHT)!



Primary Respiratory Acidosis

28

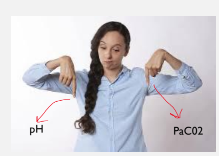
KEEP STANDING UP (OR SITTING UP STRAIGHT)!



Primary Respiratory Alkalosis

29

NOW WE CAN SIT ☺



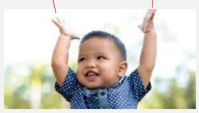
Primary Metabolic Problem
(look at $HC0_3$)

30

WE CAN CONTINUE TO SIT ☺

pH

PaC02



Primary Metabolic Problem
(look at HCO_3)

31

COMPENSATION

- After you determine the primary disturbance, look at the "other" biochemical result (C02 or HC03)
- The "other" or "secondary response" will try to redirect the pH toward the normal range.

Acid Base Disorders

Disorder	pH	$[H^+]$	Primary disturbance	Secondary response
Metabolic acidosis	↓	↑	↓ $[HCO_3^-]$	↓ pCO_2
Metabolic alkalosis	↑	↓	↑ $[HCO_3^-]$	↑ pCO_2
Respiratory acidosis	↓	↑	↑ pCO_2	↑ $[HCO_3^-]$
Respiratory alkalosis	↑	↓	↓ pCO_2	↓ $[HCO_3^-]$

32

PRACTICE QUESTIONS!

Let's wake up,

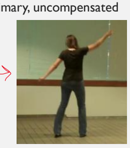
Let's dance (I'm serious),

and let's test our knowledge!

33

QUESTIONS

Which of the following arterial blood gases demonstrates a primary, uncompensated respiratory acidosis, making your dance moves look like



A. pH **7.24** PCO2 **32** PaO2 **65** HCO3 20
B. pH **7.23** PCO2 **50** PaO2 **65** HCO3 22
C. pH **7.47** PCO2 **41** PaO2 **65** HCO3 24

34

QUESTIONS

Which arterial blood gas result indicates a primary metabolic acidosis?

A. pH **7.23** PCO2 **35** PaO2 **65** HCO3 20
B. pH **7.24** PCO2 **49** PaO2 **65** HCO3 26
C. pH **7.47** PCO2 **33** PaO2 **65** HCO3 24

35

QUESTIONS

Which arterial blood gas result indicates a compensated respiratory acidosis?

a. pH **7.37** PCO2 **30** PaO2 **60** HCO3 18
b. pH **7.29** PCO2 **51** PaO2 **54** HCO3 20
c. pH **7.4** PCO2 **49** PaO2 **70** HCO3 30

36

QUESTIONS

Which of the following situations can lower the pulse oximetry reading on the bedside monitor, making a RN inclined to increase Fi02?

a. Infant with skin temperature of 36.1⁰C in an isolette
b. Infant with high gastric output from ileostomy
c. Infant with RDS and high PaC02, who needs to be intubated

37

QUESTIONS

If a newborn infant has a PaO2 of 45 with a pH of 7.21, you expect the % saturation to ____________ as the pH normalizes:

a. Decrease
b. Remain the same
c. Increase

38

QUESTIONS

Compensation by the renal buffering system:

a. Does not occur
b. Occurs within minutes
c. May take hours to days

39

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40

41

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42