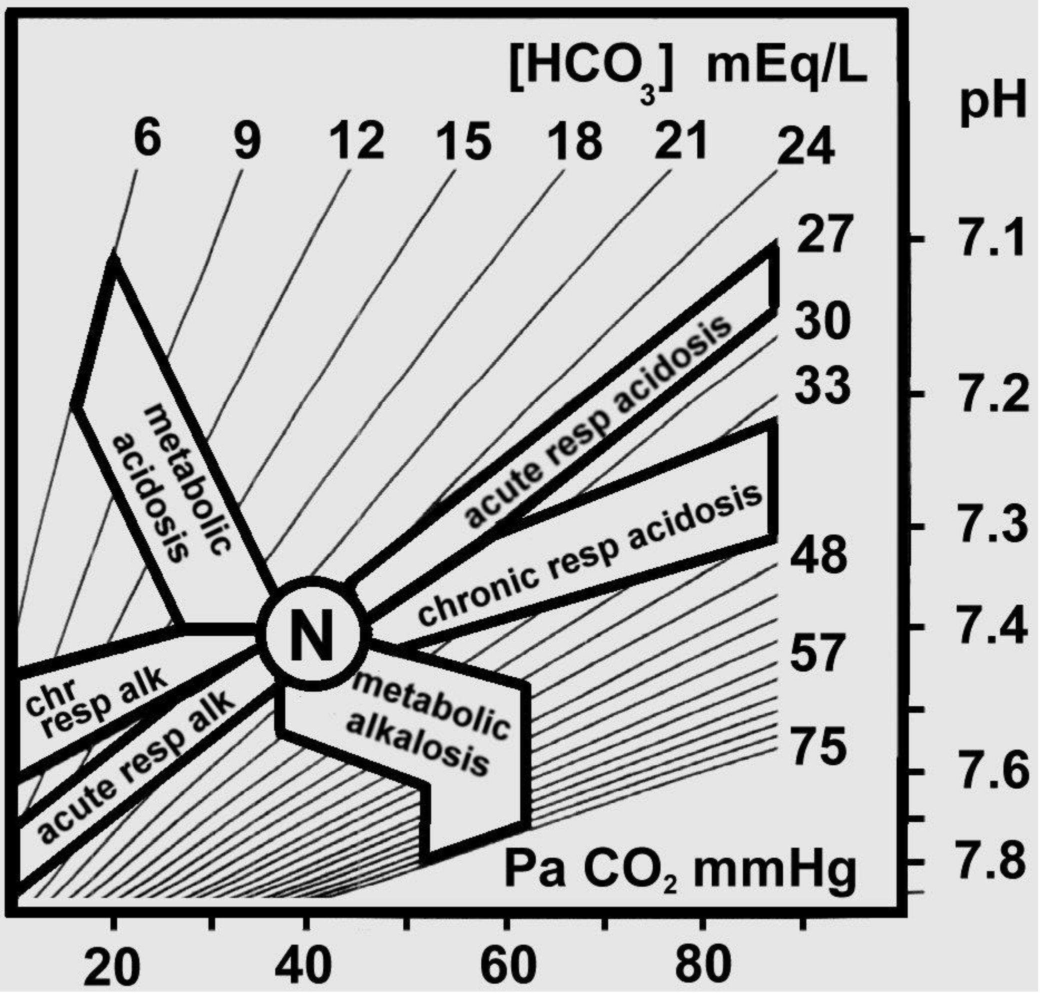
Acid-Base Balance



An Introduction and Overview to and of Blood Gas Analysis

Blood Gas Norms

Parameter	Normal Range
pO_2	80-100 mm Hg (80)
pCO_2	35-45 mm Hg (40)
pH	7.35-7.45 (7.4)
O_2 saturation	94-100%
Bicarbonate	22-26 mEq/L (24)

Introduction to Arterial Blood Gas Analysis: Acidosis and Alkalosis

- Acidosis is a condition of having too much acid in the blood – may be due to poor respiratory function or metabolic malfunction
- Alkalosis is a condition of having too much base in the blood – may be due to poor function of the respiratory system or metabolic malfunction

Acid-Base Disturbances

- Come in two types: respiratory or metabolic.
- Each type may be further subdivided into acidosis and alkalosis, hence, we now have 4 possible pure acid-base disturbances to examine.
- And this doesn't EVEN begin to get into MIXED gas states

“Respiratory”

- Whenever the term "respiratory" is used in front of acidosis or alkalosis, that means that the lungs are not functioning correctly, i.e., either retaining too much CO_2 or blowing off too much CO_2, respectively.
- Acidosis means that the arterial blood pH has gone below 7.35.
- Likewise, alkalosis means that the arterial blood pH has risen above 7.45.
- Respiratory “kicks in” within minutes; max effect 6-12 hours.

Causes of Acid-Base Disturbances -- Respiratory

Acidosis

- Hypoventilation,
- Drug overdose,
- COPD,
- Pulmonary edema

Alkalosis

- Hyperventilation,
- Pulmonary embolism,
- Asthma

Recommended Textbook for Further Reading

Shapiro, BA, Harrison, RA and Walton, JR: **Clinical Application of Blood Gases**, Third Edition (Year Book Medical Publishers, Inc: Chicago) © 1977

Realistically, First through Fourth Editions are very usable. Third Edition is in WNC's Library on Permanent Reserve, in Dr. Tattersall's Office on the Douglas Campus and in Dr. Carman's Private Home Library. Fifth Edition is horrible – new authors and Shapiro relinquished authorship control due to a health issue.

“Metabolic”

- Whenever the term “metabolic" is used in front of acidosis or alkalosis, that means that the kidneys are not functioning correctly, i.e., either retaining too much HCO_3^- or excreting too much HCO_3^-.
- Acidosis means that the arterial blood pH has gone below 7.35.
- Likewise, alkalosis means that the arterial blood pH has risen above 7.45.
- Metabolic takes 3-5 DAYS to “kick in” completely

Causes of Acid-Base Disturbances -- Metabolic

Acidosis

- Diabetic ketoacidosis,
- Lactic acidosis,
- Ingesting HCl,
- Diarrhea (excreting bicarbonate rapidly)

Alkalosis

- Vomiting (rapid loss of hydrogen ions),
- Diuretics (loss of potassium ions)
- Ingesting large amounts of bicarbonate

S/S Acid-Base Disorders

- Typically, signs and symptoms of acidosis include headache, confusion, drowsiness, nausea and vomiting.
- Signs and symptoms of alkalosis include dizziness, tingling of toes and fingers, muscle weakness/ spasm, carpopedal spasm, tetany, sweating and arrhythmias.

Physiology and Elementary Biochemistry

Background Information for Successful Comprehension of ABG Analysis

Blood Gas Value	Arterial	Venous
pH	7.35-7.4	7.30-7.40
PCO_2	35-45 mm Hg	42-48 mmHg
HCO_3	22-28 mEq/L	24-30 mEq/L
PO_2	80-100 mmHg	35-45 mm Hg

Blood and pH

- Blood is slightly alkaline.
- Arterial blood runs a pH between 7.35 and 7.45.
- In venous blood, it runs less than 7.35 due to the high amount of carbon dioxide in it. [**Add 0.035 to the venous pH to estimate the arterial pH.**]
- **The VBG has no role in the assessment of critically ill patients.**
- Protons (hydrogen ions) come from aerobic metabolism of glucose, from hydrolysis of carbonic acid, from the oxidation of sulfur containing amino acids, from the anaerobic metabolism of glucose, from lactate, from ketone bodies and from phosphate containing proteins and nucleic acids.

“p”

- The "p" in front of the O_2 and CO_2 is different from the "p" in front of the H in "pH".
- This "p" stands for the partial pressure of a gas in solution (or dissolved) in the blood.
- The O_2 saturation changes as we age.

- Under normal conditions, the bicarbonate to proton ratio is about 20 to 1 and the hydrogen ion concentration may be calculated by multiplying 24 times the ratio of pCO_2 over bicarbonate ion concentration:

$$[H^+] = 24 * \frac{pCO_2}{[HCO_3^-]}$$

- That means, then, that the pH is proportional to the ratio of bicarbonate (the metabolic contributor to pH balance) to the pCO_2 (the respiratory contributor to pH balance).

Carbon Dioxide: CO_2

- CO_2 is not normally transported as such, rather as HCO_3^-

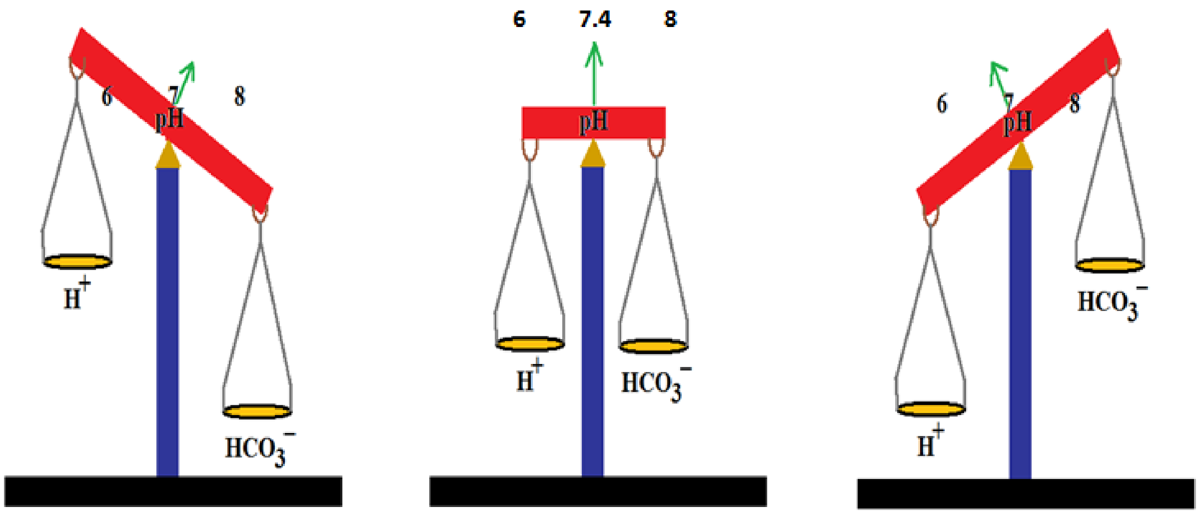
- This occurs via an enzymatic reaction catalyzed by carbonic anhydrase:

$$CO_2 + H_2O \rightarrow H_2CO_3 \rightarrow HCO_3^- + H^+$$

Condensation $\rightarrow$ Product $\rightarrow$ Partial deprotonation

- IMPORTANT in acid/base balance

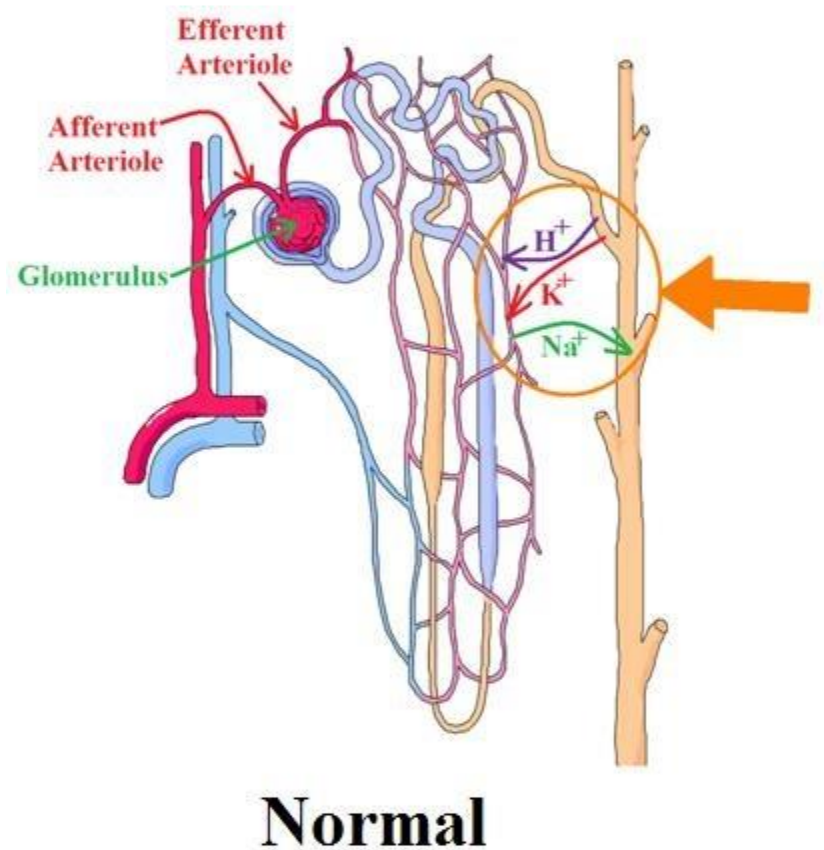
Bicarbonate, Protons and Their Relationship



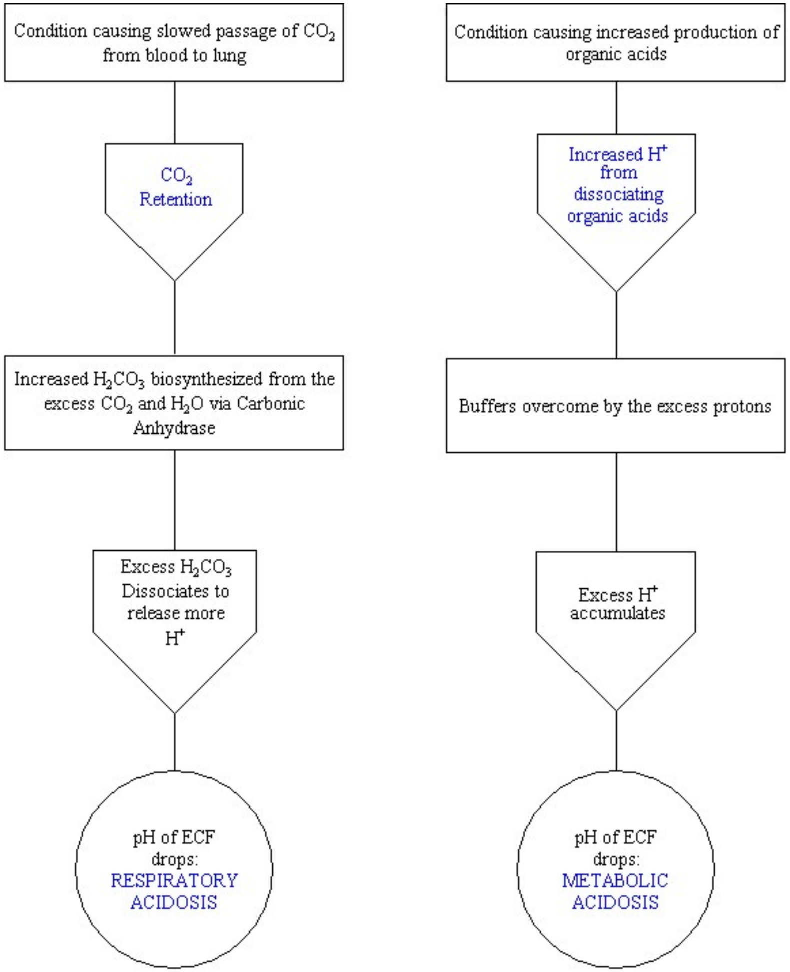
Condition:	**Alkaline**	**Normal**	**Acidic**
Bicarbonate to proton ratio:	44 to 1	20 to 1	8 to 21
Shifts to:	Right making the blood alkaline	7.35-7.45 or normal balance	Left making the blood acidic

Renal Potassium Regulation with H^+

- Conserves H^+



Normal Regulation

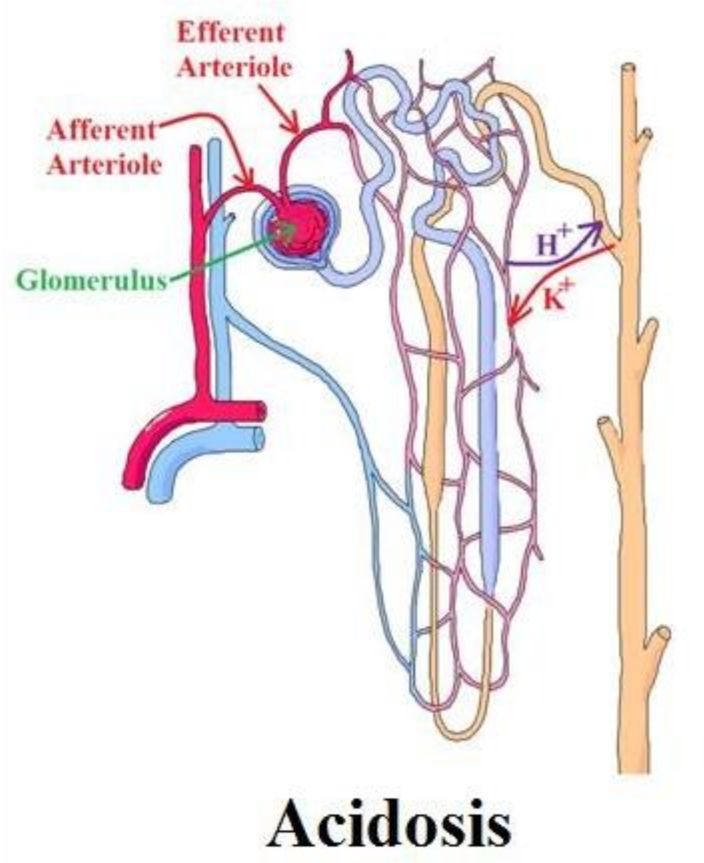


ACIDOSIS

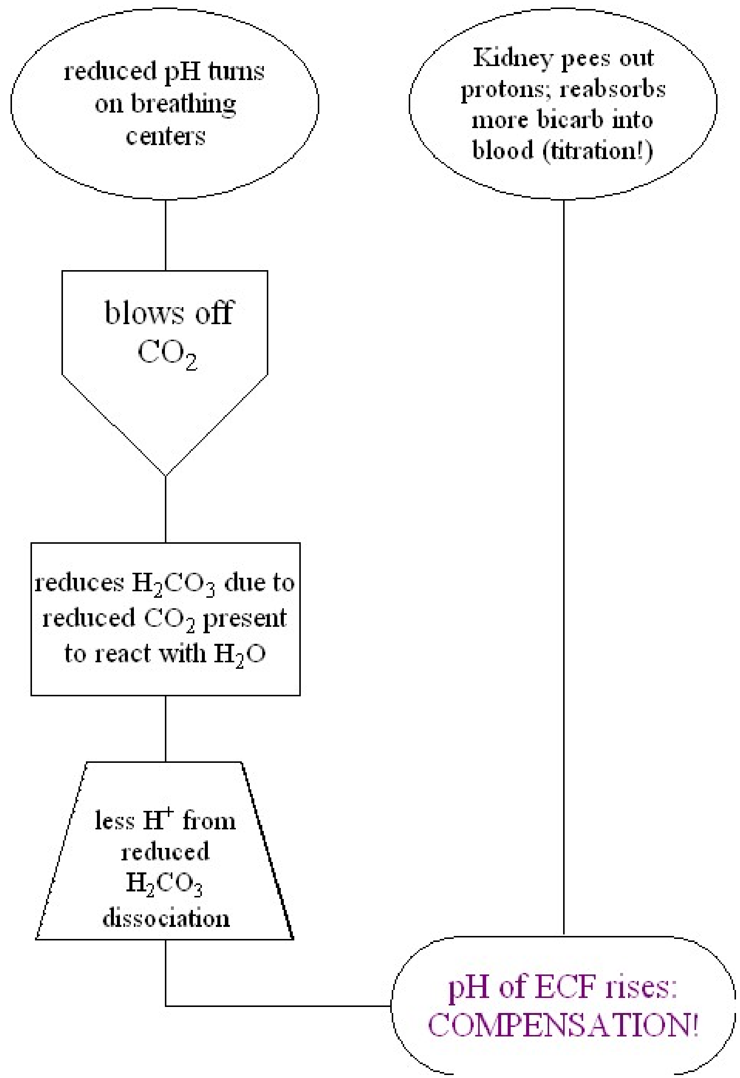
pH go down, HCO_3^- go down, pCO_2 go up

Renal Potassium Regulation in Acidosis

- K^+/H^+ exchange competition
- Hyperkalemia is often associated with acidosis
- For every 0.1 drop in pH, figger on the blood K^+ levels going UP 0.5 mEq/L

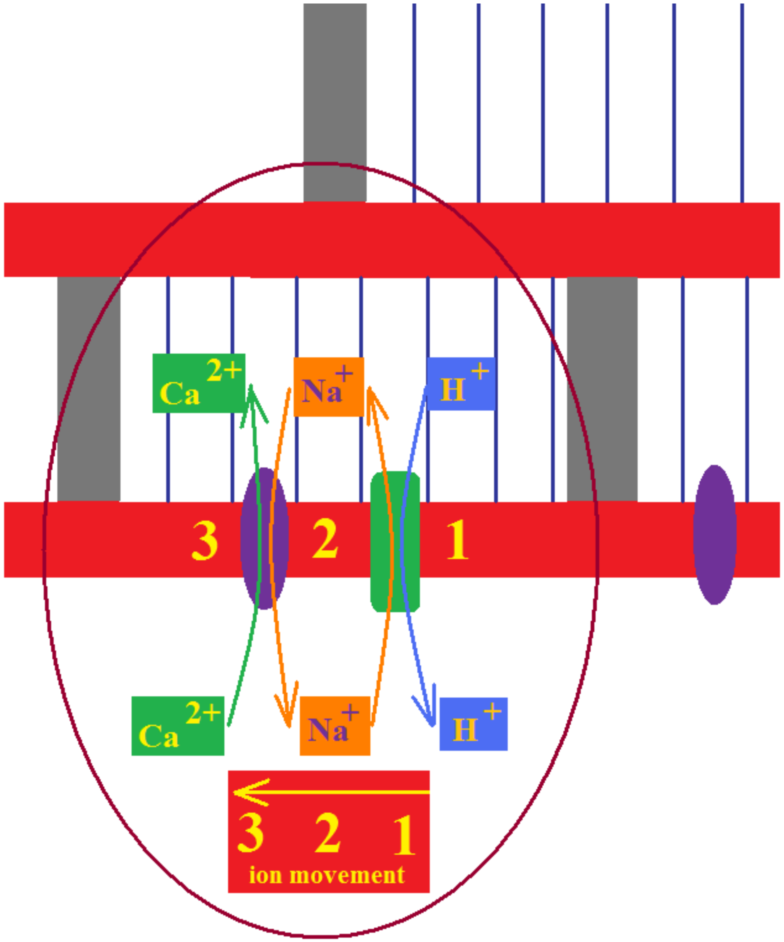


Compensatory Mechanisms for Acidosis

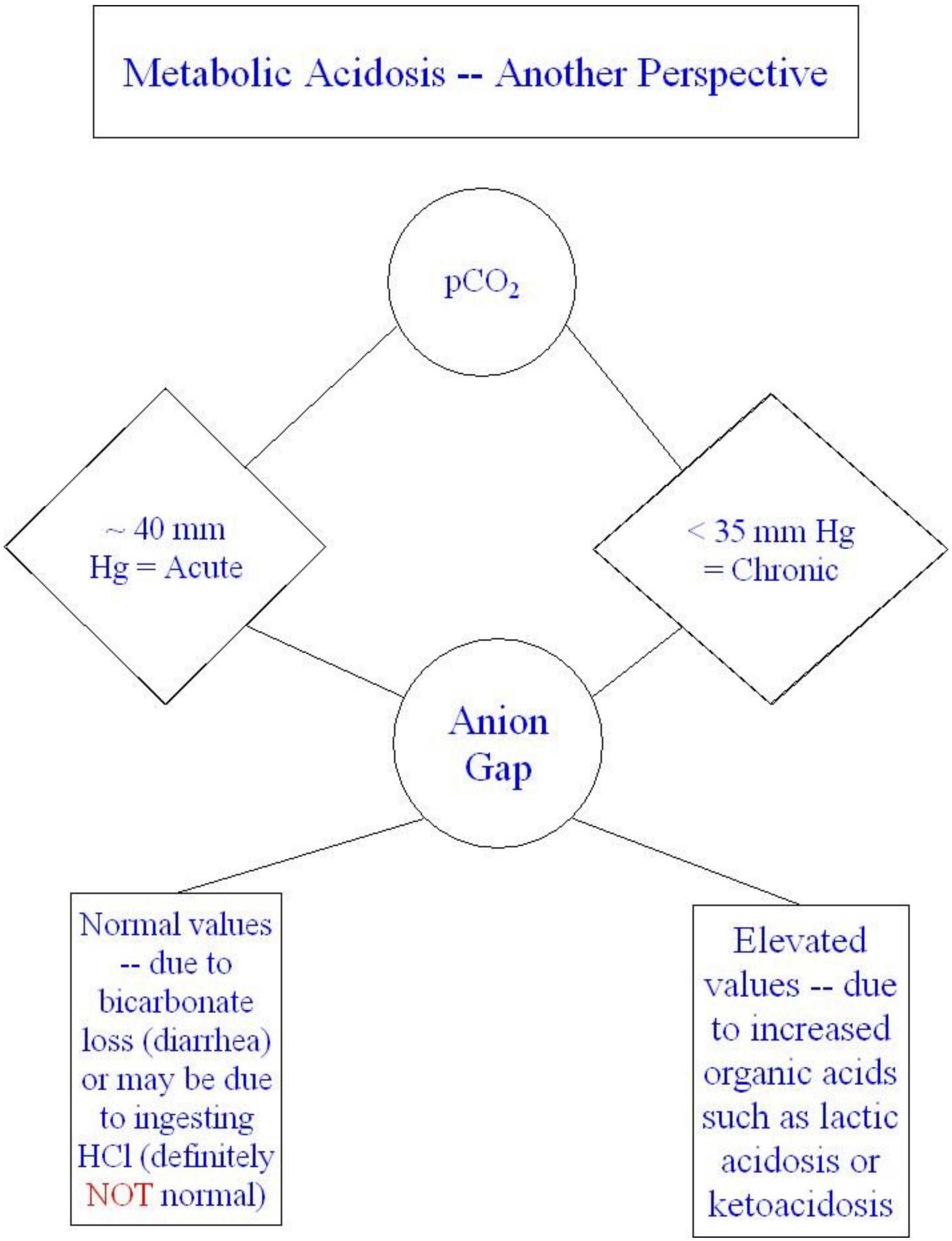


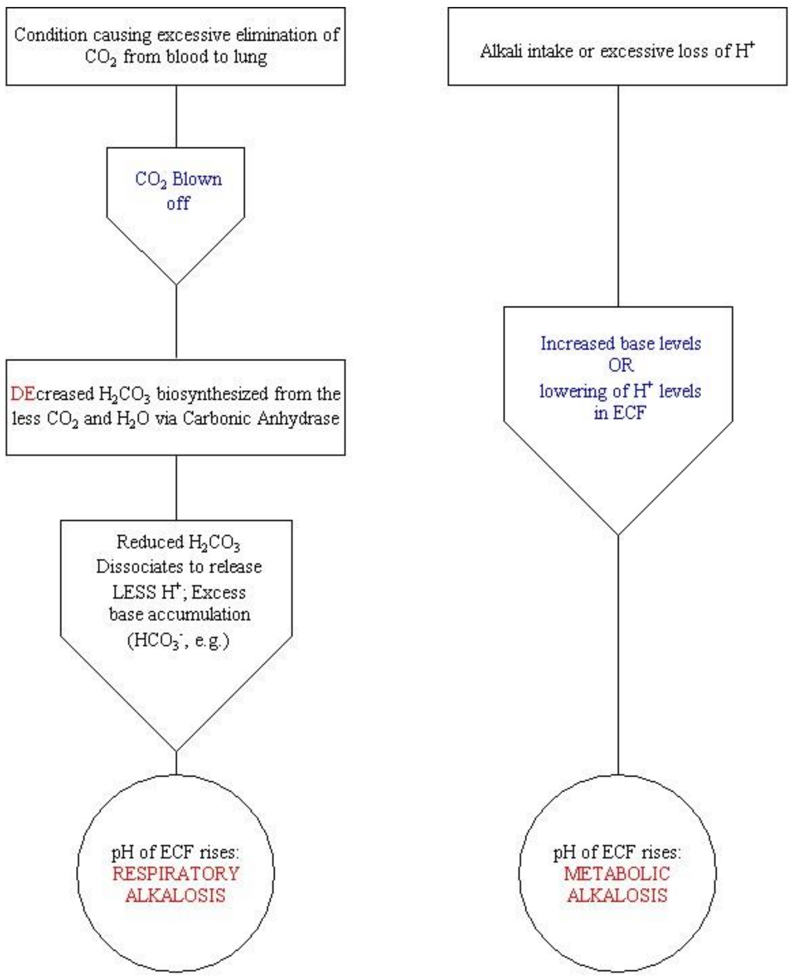
Anaerobic Myocardial Metabolism

- Elevated H^+ due to a build up of lactate and/or fatty acids contributes to a metabolic acidosis in the heart muscle
- Na^+/Ca^{2+} Exchanger
- H^+/Na^+ Exchanger
- As the H^+ are exchanged OUT of the cardiac cells, Na^+ and Ca^{2+} exchange leading to excessively high levels of Ca^{2+} in the cells which leads to cell death



Another "Add-On"



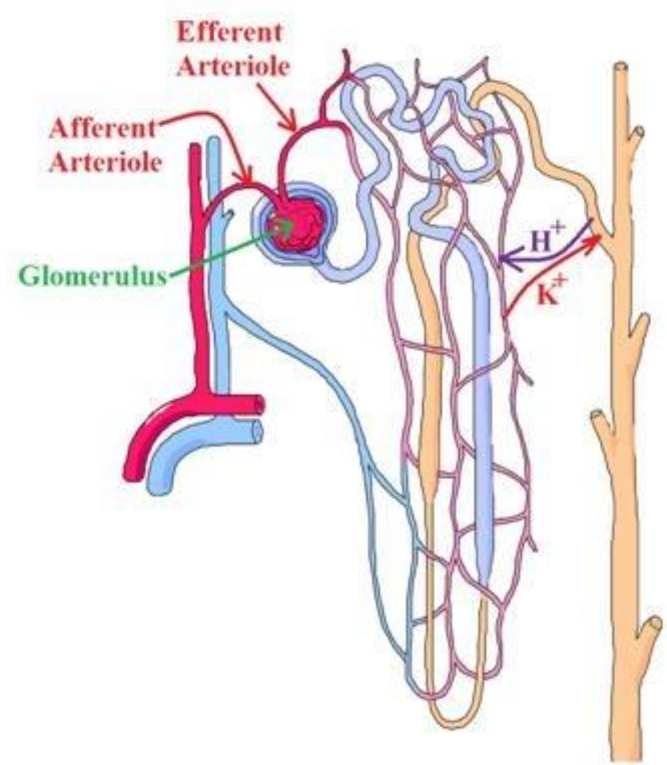


ALKALOSIS

pH go up, HCO_3^- go up, pCO_2 go down

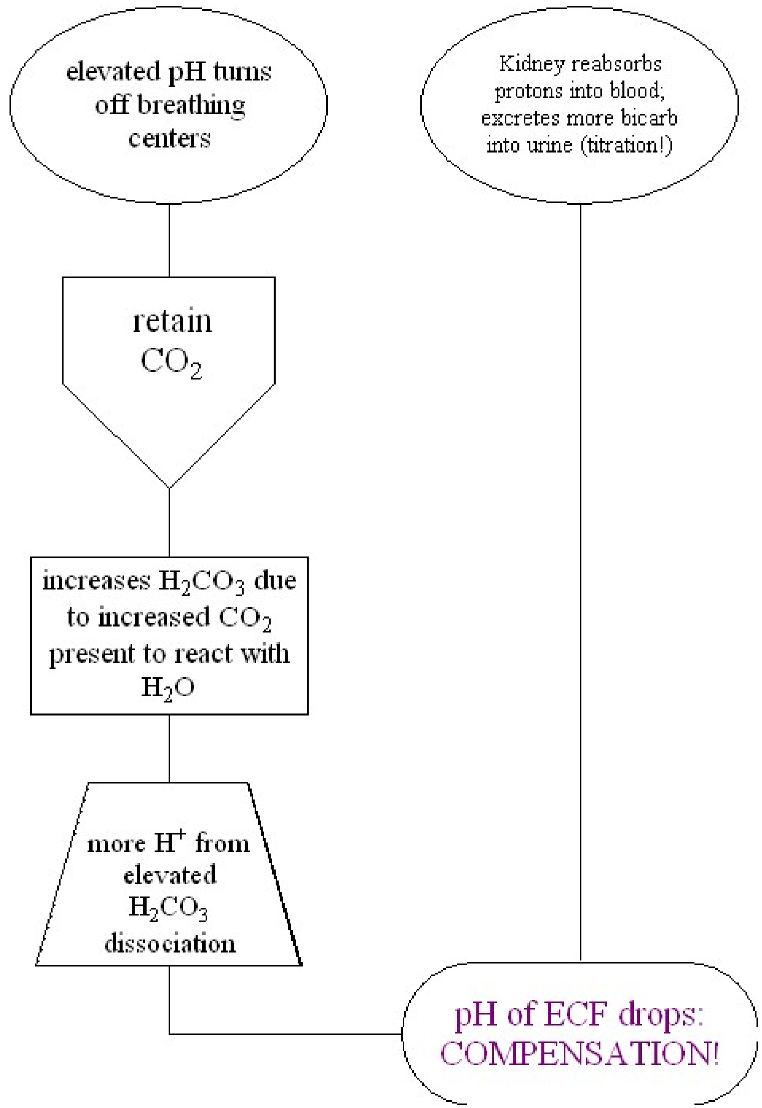
Renal Potassium Regulation in Alkalosis

- K^+/H^+ exchange competition
- Hypokalemia often associated with alkalosis
- For every 0.1 rise in pH, figger on the blood K^+ levels DROPPING 0.5 mEq/L



Alkalosis

Compensatory Mechanisms for Alkalosis



How Does One Obtain Arterial Blood Gas Data?

By drawing arterial blood!

ABG Apparatus

Kit Method

- The kit comes with everything you will need.
- Attach the needle (usually a 22-20 g needle; the 20 g is the inside measure and the 22 is the outside measure -- makes for a bit less pain on arteriopuncture without lysing red blood cells) to the syringe.
- Pull back on the plunger with rotation to line the barrel with heparin.
- Expel the heparin afterwards.
- Allow NO air bubbles to remain in the barrel.
- Proceed to arterial puncture.

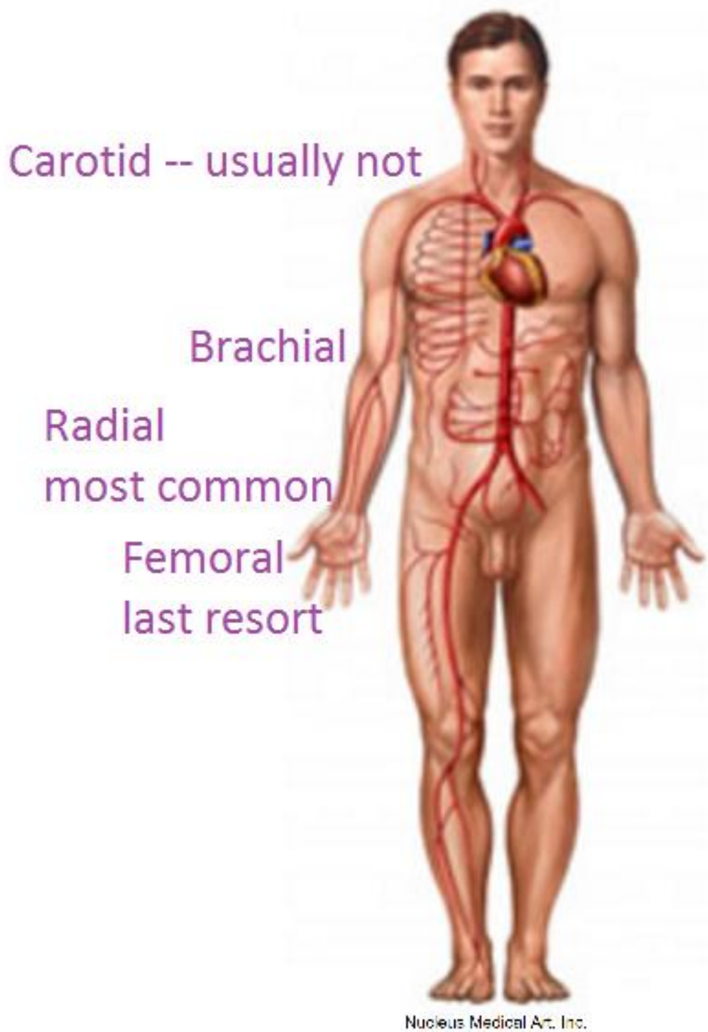
DIY Method

- The DIY method consists of attaching a 22-20 g needle to a syringe and draw up 0.5-1 mL of heparin solution into the syringe under aseptic conditions.
- Pull back on the plunger with rotation to line the barrel with heparin.
- Expel the heparin afterwards.
- Allow NO air bubbles to remain in the barrel.
- Proceed to arterial puncture.

Regardless of Method

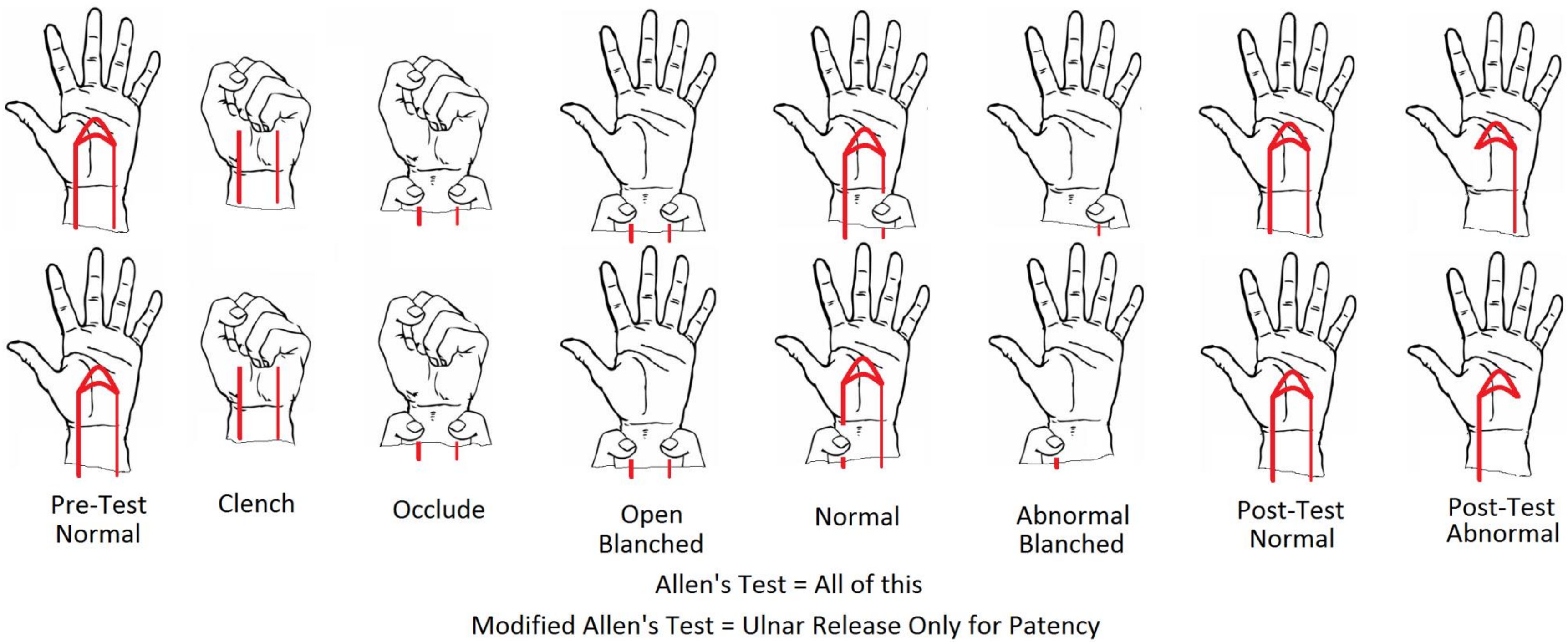
- When going back to draw an arterial blood gas (ABG), take the following with you:
  - a self-supporting bag of ice water,
  - a latex block or rubber stopper,
  - another person (to hold pressure for at least 10 minutes after you are done and to put a bandage/bandaid over the arteriopuncture site).

ABG Draw Sites



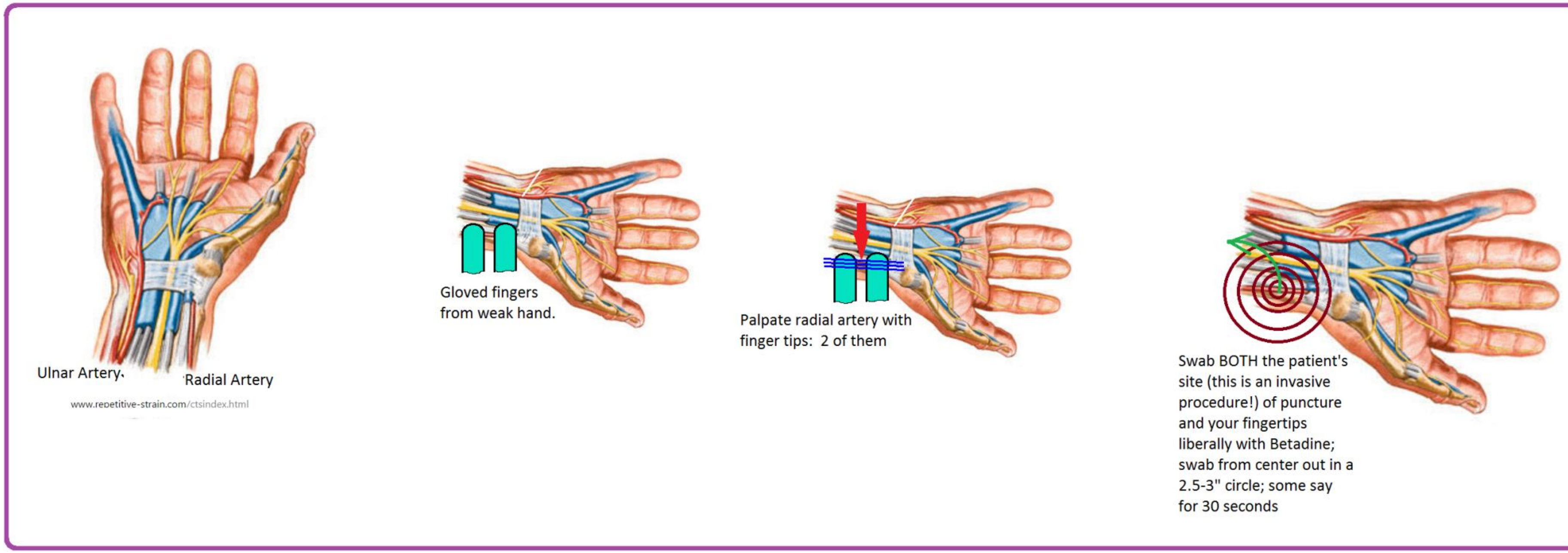
- Depends on the clinical site as to whom draws these samples – some require only the MD; others permit Resp Therapists and/or Med Techs
- Keep in mind that if the radial artery is unacceptable you will have to move to the brachial artery.
- Go to the femoral artery last -- it's the deepest and has the highest risk of throwing a clot.

[Modified] Allen's Test



- If the ulnar artery works, you can draw from the radial artery as there is back-up blood flow into the hand.
- If it doesn't, you'll have to move to the brachial artery so that you don't run the risk of blocking blood flow into the hand, causing your patient to either undergo surgery to correct your problem or, in the worst case scenario, to lose the hand.
- If the palm DOES NOT PINK UP, either try the other wrist or go to the brachial artery.
- Femoral Artery is draw site of last resort

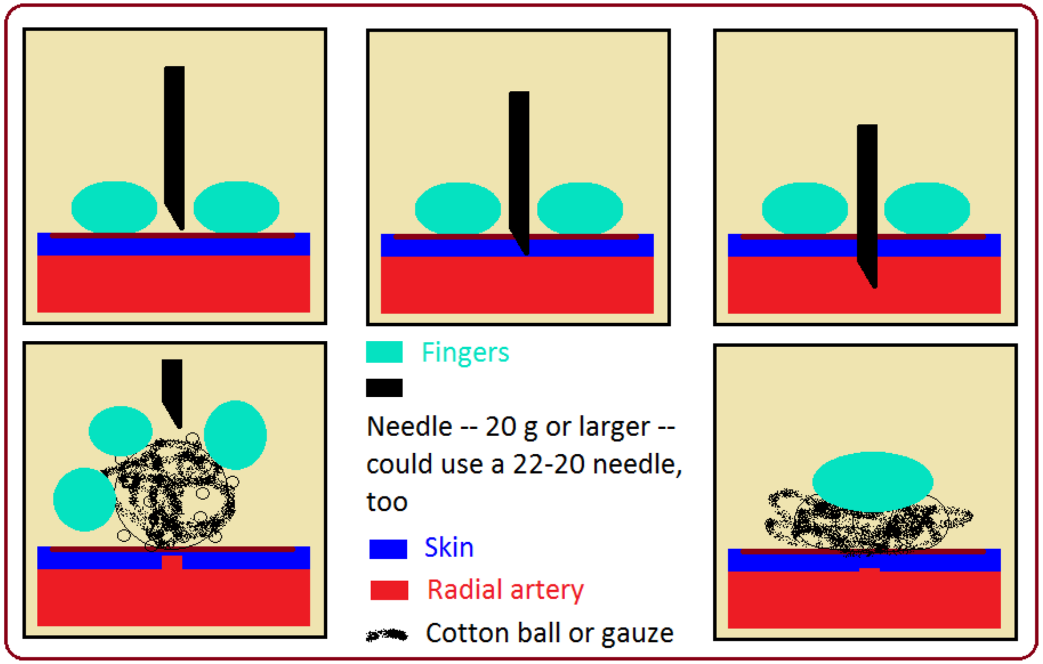
Skin Prep and Palpation



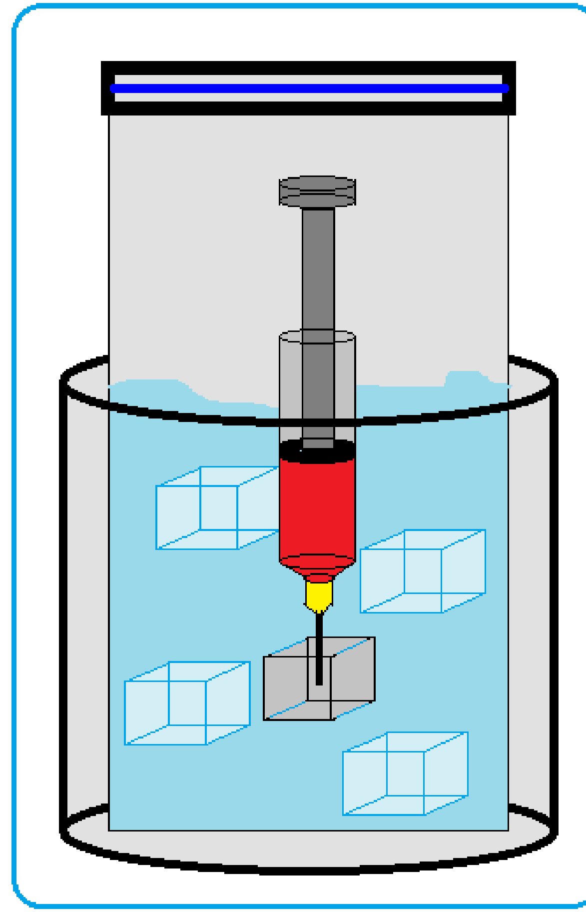
Arteriopuncture

Bevel away from face!

Slow and patient insertion -- hurts like hells!
Look for flashback; stop insertion; allow to fill on its own.



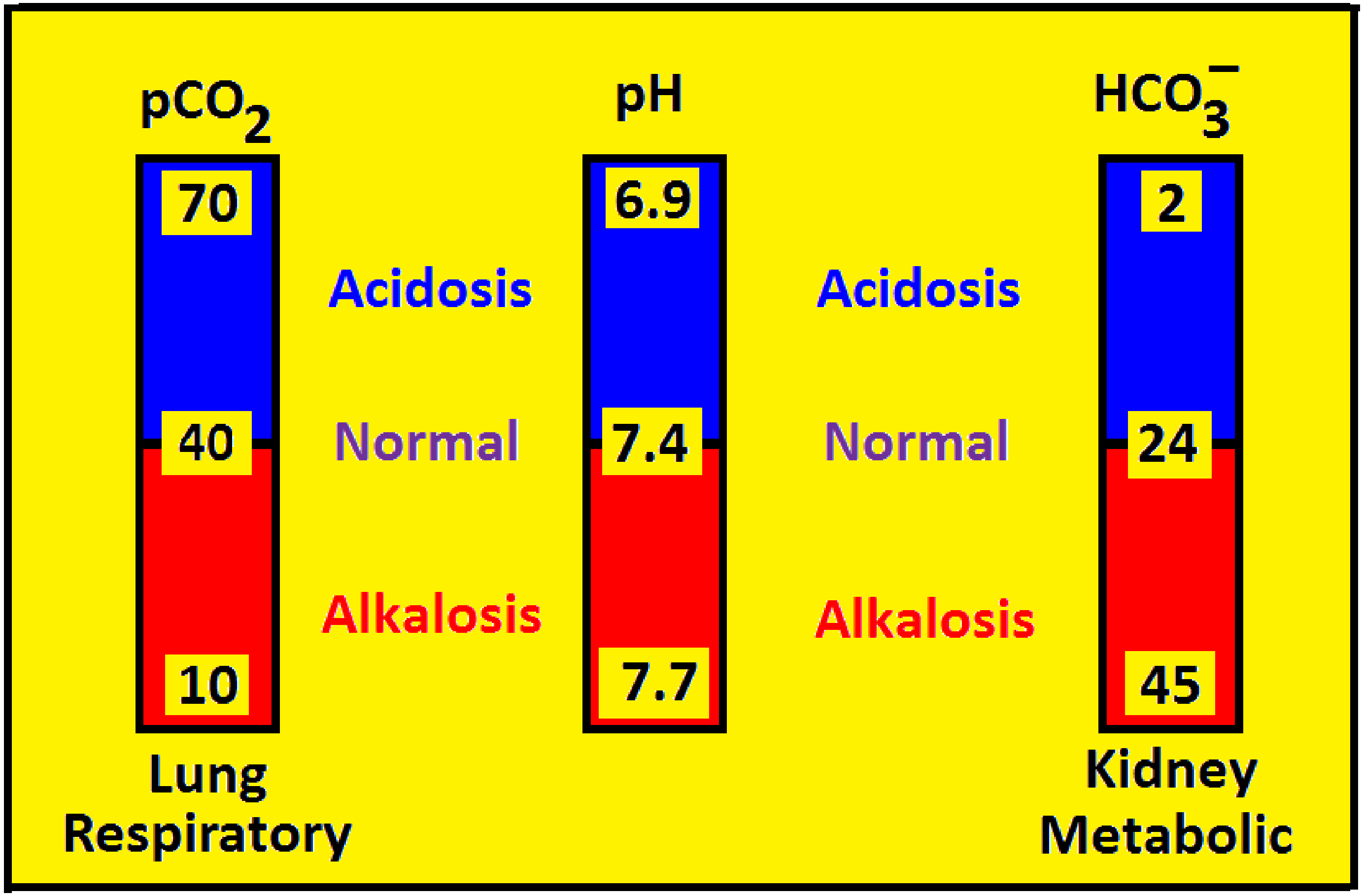
When syringe filled, simultaneously withdraw needle and place cotton ball or gauze over wound site with pressure. Have assistant put pressure on wound X 10 minutes. Expel any air bubbles. Stab needle in to latex block. Roll between fingers to mix with heparin. Place in ice water. Take to lab and analyze stat -- ABG's are never ASAP -- sample is only good for 30 minutes.



Whatcha Gonna Do, NOW?!

- Run ‘em back in the lab!
- Once the samples have been run,
- Ya gotta analyze ‘em! YIPPEE! ☺

Successful ABG Interpretation: Carman's 9-Step Program



Do ***NOT*** Get Creative with These!

Step 1

- Examine the pH:
  - if the pH is less than 7.4 the patient has acidosis;
  - if greater than 7.4, alkalosis.
- If the pH is within the normal range,
  - the condition is chronic;
- If the pH is outside the normal range,
  - the condition is acute.

Step 1 – Expansion

- In terms of pH assessment, in acute respiratory disorders, use the following rule:
- 1) the pH decreases 0.1 for every 20 mm Hg increase in pCO_2 above 40
- 2) the pH increases 0.1 for every 10 mm Hg decrease in pCO_2 below 40
- This means that when the pCO_2 is 60, the pH is 7.3 ± .
- When the pCO_2 is 80, the pH is 7.2 ± .
- When the pCO_2 is 20, the pH is 7.6 ± .
- When the pCO_2 is 10, the pH is 7.7 ± .

Step 2

- Find the primary cause of the problem by looking at the pCO_2 (for respiratory contributions) and HCO_3^- (for metabolic contributions) relative to the pH:

Acidosis (pH < 7.4)	Alkalosis (pH > 7.4)
$pCO_2 > 40$; primary cause is respiratory	$pCO_2 < 40$; primary cause is respiratory
$HCO_3^- < 24$; primary cause is metabolic	$HCO_3^- > 24$; primary cause is metabolic

- In the case of acute respiratory acidosis, a 10 mm Hg increase in pCO_2 causes a 1 mEq increase in bicarbonate levels.
- In chronic respiratory acidosis, a 10 mm Hg increase in pCO_2 causes a 4 mEq increase in bicarbonate levels.
- In acute respiratory alkalosis, a 10 mm Hg decrease in pCO_2 causes a 2 mEq decrease in bicarbonate levels.

Step 2, Example

- A patient presents to you with a pH of 7.37, a pCO_2 of 55 and a bicarbonate level of 33. Since the pH is about normal, this is a chronic condition.
- Remember: normal is chronic.
- The bicarbonate is elevated by 9 units. With the pCO_2 increased by 15, this suggests that the bicarbonate (aka bicarb) ought to be about 30.
- Since the bicarb is actually 33, this indicates that there is a compensating metabolic alkalosis on the original respiratory acidosis.

Step 2, Example

- Another patient presents to you with a pH of 7.15, pCO_2 of 75 and a bicarb of 20.
- The pCO_2 is high enough to contribute to a 0.18 drop in pH (or to 7.22).
- This suggests an acute process.
- The pCO_2 is elevated by 35 which would raise the bicarb to about 27.5.
- Since it is decreased to 20, both metabolic and respiratory acidos**e**s are present.

Step 2, Example

- A third patient presents to you with a pH of 7.55, a pCO_2 of 30 and a bicarb of 30.
- The pH is high enough for alkalosis, but it probably is NOT respiratory (with the pH elevated by 0.15, the pCO_2 ought to be 25).
- With a 10 mm Hg decrease in pCO_2, the bicarb ought to be about 22 mEq.
- Since the bicarb level is > 22 mEq, a metabolic alkalosis is present.
- **Note: When there are mixed gas states like this example, give priority to metabolic activities in your diagnoses.**

Step 2, Example

- Another patient presents to you with a pH of 7.52, pCO_2 = 50 and the patient's HCO_3^- is 32.
- This set of gases suggests a metabolic **alkalosis** with respiratory compensation.
- With respiratory compensation, the pCO2 increases above normal, but it is rarely more than 55.
- If the pCO2 is greater than 55, that suggests that a complicating respiratory acidosis is present.
- No change in pCO2 might suggest respiratory alkalosis, but it is VERY rare.

Step 3

- Determine if the patient is able to compensate (***TITRATE***!!!!!!).
- If the patient is able to compensate, the value OTHER than the one changing secondary to the primary disorder will move in the same direction as the primary value.
- What this means is that if a patient has a respiratory acidosis, the pCO_2 will be elevated.
- For compensation (***TITRATION***) to occur, the HCO_3^- must ALSO rise to balance out the respiratory imbalance with metabolic mechanisms.
- Conversely, if the patient has a metabolic alkalosis, the HCO_3^- will be elevated.
- For compensation (***TITRATION***) to occur, the pCO_2 must ALSO rise to balance out the metabolic imbalance with respiratory mechanisms.

Step 4

- If the primary disorder is metabolic acidosis, use Winter's formula for pCO_2 prediction :

$$(1.54 * [HCO_3^-]) + 8.36 \pm 1 = pCO_2$$

- If the pCO_2 is **greater than predicted**, that means there is a complicating respiratory acidosis.
- If the pCO_2 is **less than predicted**, that means that there is a complicating respiratory alkalosis.

pCO_2 Levels Above 70 mm Hg

- May decrease respirations
- May cause stupor, coma (CO_2 narcosis)
- May cause hypoxemia

- SLOWLY decrease the pCO_2 so as to not cause posthypercapnic metabolic alkalosis

Step 5

- If the primary disorder is metabolic alkalosis, and the pCO_2 is greater than 55, a complicating respiratory acidosis is present.
- If the primary disorder is metabolic alkalosis, and the pCO_2 is less than 40, a complicating respiratory alkalosis is present.

Step 6

- If the primary disorder is respiratory, estimate the presence of complicating metabolic disorders by comparing predicted and actual HCO_3^- levels:
  - A) in **acute** respiratory acidosis, each pCO_2 increase of 10 mm Hg causes the HCO_3^- to increase by 1 mEq,
  - B) in **chronic** respiratory acidosis, each pCO_2 increase of 10 mm Hg causes the HCO_3^- to increase by 4 mEq,
  - C) in **acute** respiratory alkalosis, each pCO_2 **de**crease of 10 mm Hg causes the HCO_3^- to **de**crease by **2** mEq.

Step 7

- If the complicating disorder to the respiratory disorder is metabolic acidosis, calculate the anion gap
- Anion gap = Na^+ - (Cl^- + serum CO_2 content)
- Anion gap = Na^+ - (Cl^- + HCO_3^-)
- The anion gap is used when metabolic acidosis complicates the respiratory disorder.
- Keep in mind that some authorities include the potassium ion levels with the sodium ion levels.
- Since the K^+ levels are relatively small compared to the sodium ion levels, though, it's not always used.

Anion Gap Reference RANGES		
NORMAL	Complicating Metabolic Acidosis	Ketoacidosis, lactic acidosis, salicylate poisoning, EtOH poisoning
12-14 mEq (some references begin at 8)	15-25 mEq	26 mEq and above

Anion Gap Example

- A patient presents to you with the following laboratory data: pH = 7.12, pCO_2 = 70, HCO_3^- = 22, Na^+ = 130, Cl^- = 84, CO_2 content = 24.
- The pH is low enough to be acute.
- The pCO_2 is increased 30, therefore, the pH ought to be about 7.25.
- Since it's lower, it suggests something else is going on.
- Since the pCO_2 is increased by 30, the bicarb for EITHER acute or chronic respiratory acidosis ought to increase by 3 or 12, respectively.
- It, however, DECREASES by 2.
- Since the data is there, then, do the anion gap (130 - (84 + 24) = 22).
- With the anion gap value, we can now see that there is a metabolic acidosis complicating the respiratory acidosis.

Step 8

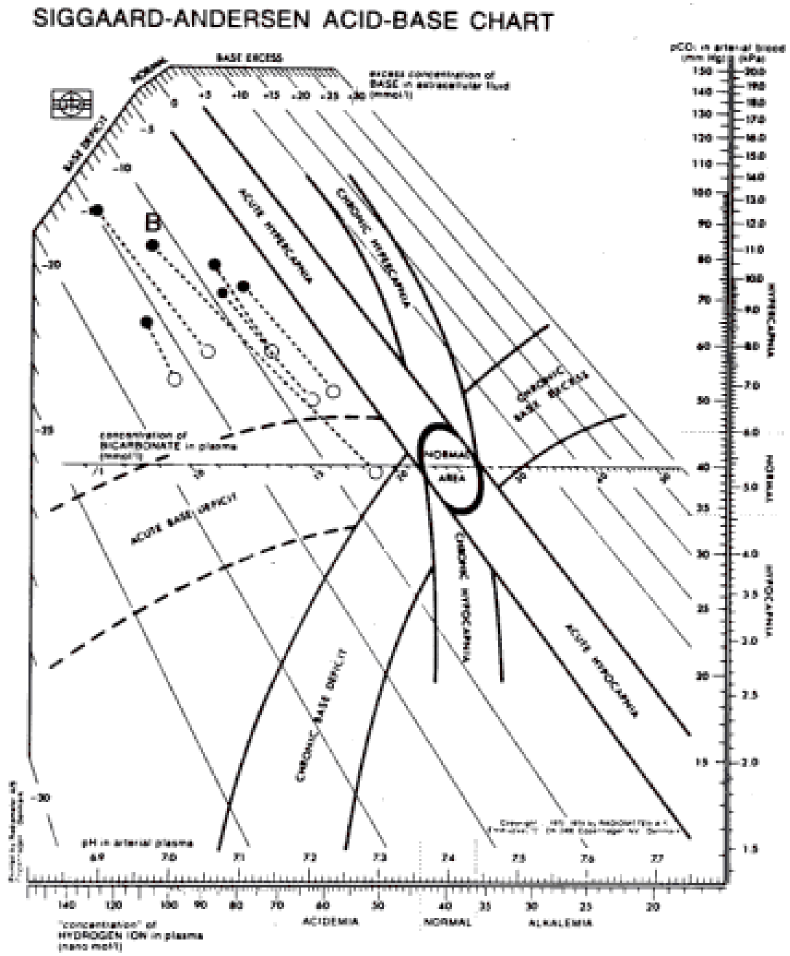
- If the primary difficulty is not obvious, both metabolic AND respiratory components may cause some type of mixed imbalance:

pH	pCO_2	HCO_3^-
7.10	50	15
Acidosis	RESPIRATORY acidosis	METABOLIC acidosis

Step 9

- Check the pO_2 for appropriate oxygenation.
- If the pO_2 is less than 80 mm Hg, the patient has hypoxemia;
- If the pO_2 is greater than 80 mm Hg, then ventilation is adequate.

Arterial Blood Gases



Analysis and Diagnosis – not all nomograms are accurate – this one was shown to over diagnose metabolic acidosis

- All of this previous text may seem rather overwhelming.
- When put in flow-chart form, or check-off form, though, it becomes quite useful and simplifies ABG interpretation.
- Blank form is on next slide.
- Examples follow after the blank slide – patient information, first, followed by the analysis form.
- ALWAYS remember that the lab data you receive in clinic is from a fellow human being – each of us is a human – NOT a number – when you begin to refer to patients as numbers you are losing your own humanity – when that's gone what's left?

NOTE: FULL Compensation = pH within Normal pH range; secondary <u>in</u> same direction as primary

NOTE: Partial/Incomplete Compensation = pH remains outside Normal pH Range – secondary <u>going</u> same direction as primary

NOTE: Uncompensation = pH outside Normal Range; pCO_2 and HCO_3^- <u>not "in sync"</u>

<table>
<tr><td colspan="8">Arterial Blood Gas Analysis Check-Off Sheet – Carry in Your Pocket – Laminate If You Like – Helps in Clinicals</td></tr>
<tr><td colspan="4">☐ pH< 7.4 = Acidosis</td><td colspan="4">☐ pH>7.4 = Alkalosis</td></tr>
<tr><td colspan="2">☐ Normal Range (7.35-7.45)
→ ☐ Chronic</td><td colspan="2">☐ Wildly Off? (< 7.35)
→ ☐ Acute</td><td colspan="2">☐ Normal Range (7.35-7.45)
→ ☐ Chronic</td><td colspan="2">☐ Wildly Off? (> 7.45)
→ ☐ Acute</td></tr>
<tr><td colspan="4">↓</td><td colspan="4">↓</td></tr>
<tr><td colspan="2">☐ pCO_2> 40</td><td colspan="2">☐ HCO_3^- < 24</td><td colspan="2">☐ pCO_2<40</td><td colspan="2">☐ HCO_3^->24</td></tr>
<tr><td colspan="2">↓</td><td colspan="2">↓</td><td colspan="2">↓</td><td colspan="2">↓</td></tr>
<tr><td colspan="2">☐ Primary Disorder is RESPIRATORY</td><td colspan="2">☐ Primary Disorder is METABOLIC</td><td colspan="2">☐ Primary Disorder is RESPIRATORY</td><td colspan="2">☐ Primary Disorder is METABOLIC</td></tr>
<tr><td colspan="4">↓</td><td colspan="4">↓</td></tr>
<tr><td>☐ Reduced HCO_3^- = Uncompensated</td><td>☐ Increased HCO_3^- = Compensated</td><td>☐ Reduced pCO_2 = Compensated</td><td>☐ Elevated pCO_2 = Uncompensated</td><td>☐ Reduced HCO_3^- = Compensated</td><td>☐ Increased HCO_3^- = Uncompensated</td><td>☐ Reduced pCO_2 = Uncompensated</td><td>☐ Elevated pCO_2 = Compensated</td></tr>
<tr><td colspan="2">↓</td><td colspan="2">↓</td><td colspan="2">↓</td><td colspan="2">↓</td></tr>
<tr><td>☐ pCO_2 increased by 10 mm Hg = HCO_3^- increase by 1 mEq</td><td>☐ pCO_2 increased by 10 mm Hg = HCO_3^- increase by 4 mEq</td><td colspan="2">☐ $pCO_2 = (1.54*HCO_3^-)+8.36 \pm 1$</td><td colspan="2">☐ pCO_2 decreased by 10 mm Hg = HCO_3^- decrease by 2 mEq</td><td>☐ pCO_2> 55</td><td>☐ pCO_2< 40</td></tr>
<tr><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td colspan="2">↓</td><td>↓</td><td>↓</td></tr>
<tr><td>☐ Acute Acidosis</td><td>☐ Chronic Acidosis</td><td>☐ pCO_2 > predicted</td><td>☐ pCO_2 < predicted</td><td colspan="2">☐ Acute alkalosis</td><td>☐ Complicating Respiratory Acidosis</td><td>☐ Complicating Respiratory Alkalosis</td></tr>
<tr><td></td><td></td><td>↓</td><td>↓</td><td colspan="4">☐ pO_2</td></tr>
<tr><td colspan="2"></td><td>☐ Complicating Respiratory Acidosis</td><td>☐ Complicating Respiratory Alkalosis</td><td colspan="2">☐ < 80 mm Hg = hypoxemia</td><td colspan="2">☐ ≥ 80 mm Hg = Adequate Ventilation</td></tr>
<tr><td colspan="8">Anion Gap = $[Na^+ - (Cl^- + HCO_3^-)]$</td></tr>
<tr><td>☐12-14: Normal</td><td colspan="3">☐15-24: Complicating Metabolic Acidosis</td><td colspan="4">☐ > 25: Ketoacidosis, Lactic Acidosis, Salicylate poisoning, Alcohol Poisoning</td></tr>
<tr><td colspan="8">DIAGNOSIS/ANALYSIS:</td></tr>
</table>

Patient Data -- #1

- This patient presents with the following data:
- pH = 7.4
- pO_2 = 85 mm Hg
- pCO_2 = 40 mm Hg
- HCO_3^- = 24 mEq/L

<table>
<tr><td colspan="8">Arterial Blood Gas Analysis Check-Off Sheet – Patient #1</td></tr>
<tr><td colspan="4">☐ pH< 7.4 = Acidosis</td><td colspan="4">☐ pH>7.4 = Alkalosis</td></tr>
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→ ☐ Chronic</td><td colspan="2">☐ Wildly Off? (< 7.35)
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→ ☐ Chronic</td><td colspan="2">☐ Wildly Off? (> 7.45)
→ ☐ Acute</td></tr>
<tr><td colspan="4">↓</td><td colspan="4">↓</td></tr>
<tr><td colspan="2">☐ pCO_2> 40</td><td colspan="2">☐ HCO_3^- < 24</td><td colspan="2">☐ pCO_2<40</td><td colspan="2">☐ HCO_3^->24</td></tr>
<tr><td colspan="2">↓</td><td colspan="2">↓</td><td colspan="2">↓</td><td colspan="2">↓</td></tr>
<tr><td colspan="2">☐ Primary Disorder is RESPIRATORY</td><td colspan="2">☐ Primary Disorder is METABOLIC</td><td colspan="2">☐ Primary Disorder is RESPIRATORY</td><td colspan="2">☐ Primary Disorder is METABOLIC</td></tr>
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<tr><td>☐ Reduced HCO_3^- = Uncompensated</td><td>☐ Increased HCO_3^- = Compensated</td><td>☐ Reduced pCO_2 = Compensated</td><td>☐ Elevated pCO_2 = Uncompensated</td><td>☐ Reduced HCO_3^- = Compensated</td><td>☐ Increased HCO_3^- = Uncompensated</td><td>☐ Reduced pCO_2 = Uncompensated</td><td>☐ Elevated pCO_2 = Compensated</td></tr>
<tr><td colspan="2">↓</td><td colspan="2">↓</td><td colspan="2">↓</td><td colspan="2">↓</td></tr>
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<tr><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td colspan="2">↓</td><td>↓</td><td>↓</td></tr>
<tr><td>☐ Acute Acidosis</td><td>☐ Chronic Acidosis</td><td>☐ pCO_2 > predicted</td><td>☐ pCO_2 < predicted</td><td colspan="2">☐ Acute alkalosis</td><td>☐ Complicating Respiratory Acidosis</td><td>☐ Complicating Respiratory Alkalosis</td></tr>
<tr><td></td><td></td><td>↓</td><td>↓</td><td colspan="4"><u>☐ pO_2</u></td></tr>
<tr><td colspan="2"></td><td>☐
Complicating Respiratory Acidosis</td><td>☐
Complicating Respiratory Alkalosis</td><td colspan="2">☐ < 80 mm Hg = hypoxemia</td><td colspan="2"><u>☐ ≥ 80 mm Hg = Adequate Ventilation</u></td></tr>
<tr><td colspan="8">Anion Gap = [Na^+ - (Cl^- + HCO_3^-)]</td></tr>
<tr><td>☐12-14: Normal</td><td colspan="3">☐15-24: Complicating Metabolic Acidosis</td><td colspan="4">☐ > 25: Ketoacidosis, Lactic Acidosis, Salicylate poisoning, Alcohol Poisoning</td></tr>
<tr><td colspan="8">DIAGNOSIS/ANALYSIS: <u>NORMAL</u></td></tr>
</table>

Patient Data -- #2

- This 22 YOF who is comatose due to ASA OD with aspiration presents with the following data:
- pH = 7.5
- pO_2 = 50 mm Hg
- pCO_2 = 30 mm Hg
- HCO_3^- = 20 mEq/L
- Na^+ = 122 mEq/L
- Cl^- = 80 mEq/L
- CO_2 = 10 mEq/L

NOTE

- Serum CO_2 content can run amuck simply due to panic:

- May be less than 15 mEq/L
- May be greater than 40 mEq/L

- Source: **Current Medical Diagnosis and Treatment**, 37th Edition (Appleton and Lange: Stamford) ©1998

Arterial Blood Gas Analysis Check-Off Sheet – Patient #2

☐ pH< 7.4 = Acidosis				**☐ pH>7.4 = Alkalosis**			
☐ Normal Range (7.35-7.45) → ☐ Chronic		☐ Wildly Off? (< 7.35) → ☐ Acute		☐ Normal Range (7.35-7.45) → ☐ Chronic		**☐ Wildly Off? (> 7.45) → ☐ Acute**	
↓				↓			
☐ pCO_2> 40		☐ HCO_3^- < 24		**☐ pCO_2<40**		☐ HCO_3^->24	
↓		↓		↓		↓	
☐ Primary Disorder is RESPIRATORY		☐ Primary Disorder is METABOLIC		**☐ Primary Disorder is RESPIRATORY**		☐ Primary Disorder is METABOLIC	
↓				↓			
☐ Reduced HCO_3^- = Uncompensated	☐ Increased HCO_3^- = Compensated	☐ Reduced pCO_2 = Compensated	☐ Elevated pCO_2 = Uncompensated	**☐ Reduced HCO_3^- = Compensated**	☐ Increased HCO_3^- = Uncompensated	☐ Reduced pCO_2 = Uncompensated	☐ Elevated pCO_2 = Compensated
↓		↓		↓		↓	
☐ pCO_2 increased by 10 mm Hg = HCO_3^- increase by 1 mEq	☐ pCO_2 increased by 10 mm Hg = HCO_3^- increase by 4 mEq	☐ $pCO_2 = (1.54*HCO_3^-)+8.36\pm 1$		☐ pCO_2 decreased by 10 mm Hg = HCO_3^- decrease by 2 mEq		☐ pCO_2> 55	☐ pCO_2< 40
↓	↓	↓	↓	↓		↓	↓
☐ Acute Acidosis	☐ Chronic Acidosis	☐ pCO_2 > predicted	☐ pCO_2 < predicted	☐ Acute alkalosis		☐ Complicating Respiratory Acidosis	**☐ Complicating Respiratory Alkalosis**
		↓	↓	**☐ pO_2**			
		☐ Complicating Respiratory Acidosis	☐ Complicating Respiratory Alkalosis	**☐ < 80 mm Hg = hypoxemia**		☐ ≥ 80 mm Hg = Adequate Ventilation	
Anion Gap = [Na^+ - (Cl^- + HCO_3^-)]							
☐12-14: Normal	☐15-24: Complicating Metabolic Acidosis			**☐ > 25: Ketoacidosis, Lactic Acidosis, Salicylate poisoning, Alcohol Poisoning**			
DIAG/ANALYSIS: Acute respiratory alkalosis with incomplete compensation and complicating metabolic acidosis – salicylate poisoning; Anion Gap = 32; hypoxic							

Patient Data -- #3

- This patient's CC is anxiety, disoriented, facial lacerations, left hemothorax with probable internal injuries due to a car collision/wreck and presents with the following data:
- pH = 7.15
- pO_2 = 84 mm Hg
- pCO_2 = 50 mm Hg
- HCO_3^- = 25 mEq/L

Arterial Blood Gas Analysis Check-Off Sheet – Patient #3

☐ pH< 7.4 = Acidosis				☐ pH>7.4 = Alkalosis			
☐ Normal Range (7.35-7.45) → ☐ Chronic		**☐ Wildly Off? (< 7.35) → ☐ Acute**		☐ Normal Range (7.35-7.45) → ☐ Chronic		☐ Wildly Off? (> 7.45) → ☐ Acute	
↓				↓			
☐ pCO_2> 40		☐ HCO_3^- < 24		☐ pCO_2<40		☐ HCO_3^->24	
↓		↓		↓		↓	
☐ Primary Disorder is RESPIRATORY		☐ Primary Disorder is METABOLIC		☐ Primary Disorder is RESPIRATORY		☐ Primary Disorder is METABOLIC	
↓				↓			
☐ Reduced HCO_3^- = Uncompensated	**☐ Increased HCO_3^- = Compensated**	☐ Reduced pCO_2 = Compensated	☐ Elevated pCO_2 = Uncompensated	☐ Reduced HCO_3^- = Compensated	☐ Increased HCO_3^- = Uncompensated	☐ Reduced pCO_2 = Uncompensated	☐ Elevated pCO_2 = Compensated
↓		↓		↓		↓	
☐ pCO_2 increased by 10 mm Hg = HCO_3^- increase by 1 mEq	☐ pCO_2 increased by 10 mm Hg = HCO_3^- increase by 4 mEq	☐ $pCO_2 = (1.54*HCO_3^-)+8.36 \pm 1$		☐ pCO_2 decreased by 10 mm Hg = HCO_3^- decrease by 2 mEq		☐ pCO_2> 55	☐ pCO_2< 40
↓	↓	↓	↓	↓		↓	↓
☐ Acute Acidosis	☐ Chronic Acidosis	☐ pCO_2 > predicted	☐ pCO_2 < predicted	☐ Acute alkalosis		☐ Complicating Respiratory Acidosis	☐ Complicating Respiratory Alkalosis
		↓	↓	**☐ pO_2**			
		☐ Complicating Respiratory Acidosis	☐ Complicating Respiratory Alkalosis	☐ < 80 mm Hg = hypoxemia		**☐ ≥ 80 mm Hg = Adequate Ventilation**	
Anion Gap = $[Na^+ - (Cl^- + HCO_3^-)]$							
☐12-14: Normal	☐15-24: Complicating Metabolic Acidosis			☐ > 25: Ketoacidosis, Lactic Acidosis, Salicylate poisoning, Alcohol Poisoning			
DIAGNOSIS/ANALYSIS: Acute respiratory acidosis with incomplete metabolic compensation; adequate ventilation							

Patient Data -- #4

- This patient's CC is chronic bronchitis with an hx of CHF (dig and lasix), is cyanotic with SOB with probably atelectasis due to pneumonia, is hyperkalemic and hypochloremic and presents with the following data:
- pH = 7.38
- pO_2 = 110 mm Hg
- pCO_2 = 76 mm Hg
- HCO_3^- = 42 mEq/L

Arterial Blood Gas Analysis Check-Off Sheet -- Patient #4							
☐ pH< 7.4 = Acidosis				☐ pH>7.4 = Alkalosis			
☐ Normal Range (7.35-7.45) → ☐ Chronic		☐ Wildly Off? (< 7.35) → ☐ Acute		☐ Normal Range (7.35-7.45) → ☐ Chronic		☐ Wildly Off? (> 7.45) → ☐ Acute	
↓				↓			
☐ pCO_2> 40		☐ HCO_3^- < 24		☐ pCO_2<40		☐ HCO_3^->24	
↓		↓		↓		↓	
☐ Primary Disorder is RESPIRATORY		☐ Primary Disorder is METABOLIC		☐ Primary Disorder is RESPIRATORY		☐ Primary Disorder is METABOLIC	
↓				↓			
☐ Reduced HCO_3^- = Uncompensated	**☐ Increased HCO_3^- = Compensated**	☐ Reduced pCO_2 = Compensated	☐ Elevated pCO_2 = Uncompensated	☐ Reduced HCO_3^- = Compensated	☐ Increased HCO_3^- = Uncompensated	☐ Reduced pCO_2 = Uncompensated	☐ Elevated pCO_2 = Compensated
↓		↓		↓		↓	
☐ pCO_2 increased by 10 mm Hg = HCO_3^- increase by 1 mEq	**☐ pCO_2 increased by 10 mm Hg = HCO_3^- increase by 4 mEq**	☐ $pCO_2 = (1.54*HCO_3^-)+8.36 \pm 1$		☐ pCO_2 decreased by 10 mm Hg = HCO_3^- decrease by 2 mEq		☐ pCO_2> 55	☐ pCO_2< 40
↓	↓	↓	↓	↓		↓	↓
☐ Acute Acidosis	**☐ Chronic Acidosis**	☐ pCO_2 > predicted	☐ pCO_2 < predicted	☐ Acute alkalosis		☐ Complicating Respiratory Acidosis	☐ Complicating Respiratory Alkalosis
		↓	↓	**☐ pO_2**			
		☐ Complicating Respiratory Acidosis	☐ Complicating Respiratory Alkalosis	☐ < 80 mm Hg = hypoxemia		**☐ ≥ 80 mm Hg = Adequate Ventilation**	
Anion Gap = $[Na^+ - (Cl^- + HCO_3^-)]$							
☐12-14: Normal	☐15-24: Complicating Metabolic Acidosis			☐ > 25: Ketoacidosis, Lactic Acidosis, Salicylate poisoning, Alcohol Poisoning			
DIAGNOSIS/ANALYSIS: Chronic respiratory acidosis with metabolic compensation (bicarb is a little high – ought to be about 38 and is 42); high oxygen							

Patient Data -- #5

- This patient's CC is N/V and dehydration due to acute intestinal infection and presents with the following data:
- pH = 7.62
- pO_2 = 86 mm Hg
- pCO_2 = 48 mm Hg
- HCO_3^- = 25 mEq/L

Arterial Blood Gas Analysis Check-Off Sheet – Patient #5

☐ pH< 7.4 = Acidosis				**☐ pH>7.4 = Alkalosis**			
☐ Normal Range (7.35-7.45) → ☐ Chronic		☐ Wildly Off? (< 7.35) → ☐ Acute		☐ Normal Range (7.35-7.45) → ☐ Chronic		**☐ Wildly Off? (> 7.45) → ☐ Acute**	
↓				↓			
☐ pCO_2> 40		☐ HCO_3^- < 24		☐ pCO_2<40		**☐ HCO_3^->24**	
↓		↓		↓		↓	
☐ Primary Disorder is RESPIRATORY		☐ Primary Disorder is METABOLIC		☐ Primary Disorder is RESPIRATORY		**☐ Primary Disorder is METABOLIC**	
↓				↓			
☐ Reduced HCO_3^- = Uncompensated	☐ Increased HCO_3^- = Compensated	☐ Reduced pCO_2 = Compensated	☐ Elevated pCO_2 = Uncompensated	☐ Reduced HCO_3^- = Compensated	☐ Increased HCO_3^- = Uncompensated	☐ Reduced pCO_2 = Uncompensated	**☐ Elevated pCO_2 = Compensated**
↓		↓		↓		↓	
☐ pCO_2 increased by 10 mm Hg = HCO_3^- increase by 1 mEq	☐ pCO_2 increased by 10 mm Hg = HCO_3^- increase by 4 mEq	☐ $pCO_2 = (1.54*HCO_3^-)+8.36 \pm 1$		☐ pCO_2 decreased by 10 mm Hg = HCO_3^- decrease by 2 mEq		☐ pCO_2> 55	☐ pCO_2< 40
↓	↓	↓	↓	↓		↓	↓
☐ Acute Acidosis	☐ Chronic Acidosis	☐ pCO_2 > predicted	☐ pCO_2 < predicted	☐ Acute alkalosis		☐ Complicating Respiratory Acidosis	☐ Complicating Respiratory Alkalosis
		↓	↓	**☐ pO_2**			
		☐ Complicating Respiratory Acidosis	☐ Complicating Respiratory Alkalosis	☐ < 80 mm Hg = hypoxemia		**☐ ≥ 80 mm Hg = Adequate Ventilation**	
Anion Gap = [Na^+ - (Cl^- + HCO_3^-)]							
☐12-14: Normal	☐15-24: Complicating Metabolic Acidosis			☐ > 25: Ketoacidosis, Lactic Acidosis, Salicylate poisoning, Alcohol Poisoning			
DIAGNOSIS/ANALYSIS: **Equivocal pCO_2 – acute metabolic alkalosis with partial respiratory compensation – adequate oxygenation**							

Patient Data -- #6

- This patient presents with the odor of EtOH on his/her breath, hypotension, oliguria and N/V with the following data:
- pH = 7.28
- pO_2 = 90 mm Hg
- pCO_2 = 23 mm Hg
- HCO_3^- = 9 mEq/L
- Na^+ = 122 mEq/L
- Cl^- = 80 mEq/L
- CO_2 = 10 mEq/L

Arterial Blood Gas Analysis Check-Off Sheet – Patient #6

<table>
<tr><td colspan="4">☐ <u>**pH< 7.4 = Acidosis**</u></td><td colspan="4">☐ pH>7.4 = Alkalosis</td></tr>
<tr><td colspan="2">☐ Normal Range (7.35-7.45)
→ ☐ Chronic</td><td colspan="2">☐ <u>**Wildly Off? (< 7.35)**</u>
<u>**→ ☐ Acute**</u></td><td colspan="2">☐ Normal Range (7.35-7.45)
→ ☐ Chronic</td><td colspan="2">☐ Wildly Off? (> 7.45)
→ ☐ Acute</td></tr>
<tr><td colspan="4">↓</td><td colspan="4">↓</td></tr>
<tr><td colspan="2">☐ pCO_2> 40</td><td colspan="2">☐ <u>**HCO_3^- < 24**</u></td><td colspan="2">☐ pCO_2<40</td><td colspan="2">☐ HCO_3^->24</td></tr>
<tr><td colspan="2">↓</td><td colspan="2">↓</td><td colspan="2">↓</td><td colspan="2">↓</td></tr>
<tr><td colspan="2">☐ Primary Disorder is RESPIRATORY</td><td colspan="2">☐ <u>**Primary Disorder is METABOLIC**</u></td><td colspan="2">☐ Primary Disorder is RESPIRATORY</td><td colspan="2">☐ Primary Disorder is METABOLIC</td></tr>
<tr><td colspan="4">↓</td><td colspan="4">↓</td></tr>
<tr><td>☐ Reduced HCO_3^- = Uncompensated</td><td>☐ Increased HCO_3^- = Compensated</td><td>☐ <u>**Reduced pCO_2 = Compensated**</u></td><td>☐ Elevated pCO_2 = Uncompensated</td><td>☐ Reduced HCO_3^- = Compensated</td><td>☐ Increased HCO_3^- = Uncompensated</td><td>☐ Reduced pCO_2 = Uncompensated</td><td>☐ Elevated pCO_2 = Compensated</td></tr>
<tr><td colspan="2">↓</td><td colspan="2">↓</td><td colspan="2">↓</td><td colspan="2">↓</td></tr>
<tr><td>☐ pCO_2 increased by 10 mm Hg = HCO_3^- increase by 1 mEq</td><td>☐ pCO_2 increased by 10 mm Hg = HCO_3^- increase by 4 mEq</td><td colspan="2">☐<u>**pCO_2 = (1.54*HCO_3^-)+8.36± 1**</u>

<u>**Predicted = 20-22 mEq/L**</u></td><td colspan="2">☐ pCO_2 decreased by 10 mm Hg = HCO_3^- decrease by 2 mEq</td><td>☐ pCO_2> 55</td><td>☐ pCO_2< 40</td></tr>
<tr><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td colspan="2">↓</td><td>↓</td><td>↓</td></tr>
<tr><td>☐ Acute Acidosis</td><td>☐ Chronic Acidosis</td><td>☐ <u>**pCO_2 > predicted**</u></td><td>☐ pCO_2 < predicted</td><td colspan="2">☐ Acute alkalosis</td><td>☐ Complicating Respiratory Acidosis</td><td>☐ Complicating Respiratory Alkalosis</td></tr>
<tr><td></td><td></td><td>↓</td><td>↓</td><td colspan="4">☐ <u>**pO_2**</u></td></tr>
<tr><td colspan="2"></td><td>☐ <u>**Complicating Respiratory Acidosis**</u></td><td>☐ Complicating Respiratory Alkalosis</td><td colspan="2">☐ < 80 mm Hg = hypoxemia</td><td colspan="2">☐ <u>**≥ 80 mm Hg = Adequate Ventilation**</u></td></tr>
<tr><td colspan="8">**Anion Gap = [Na^+ - (Cl^- + HCO_3^-)]**</td></tr>
<tr><td>☐12-14: Normal</td><td colspan="3">☐15-24: Complicating Metabolic Acidosis</td><td colspan="4">☐ <u>**> 25: Ketoacidosis, Lactic Acidosis, Salicylate poisoning, Alcohol Poisoning**</u></td></tr>
<tr><td colspan="8">**DIAGNOSIS/ANALYSIS: Acute metabolic acidosis; early/partial respiratory compensation; EtOH intoxication; adequate ventilation**</td></tr>
</table>

Patient Data -- #7

- This patient presents with the following data:
- pH = 7.42
- pO_2 = 60 mm Hg
- pCO_2 = 50 mm Hg
- HCO_3^- = 31 mEq/L

Arterial Blood Gas Analysis Check-Off Sheet = Patient #7							
☐ pH< 7.4 = Acidosis				**☐ pH>7.4 = Alkalosis**			
☐ Normal Range (7.35-7.45) → ☐ Chronic		☐ Wildly Off? (< 7.35) → ☐ Acute		**☐ Normal Range (7.35-7.45) → ☐ Chronic**		☐ Wildly Off? (> 7.45) → ☐ Acute	
↓				↓			
☐ pCO_2> 40		☐ HCO_3^- < 24		☐ pCO_2<40		**☐ HCO_3^->24**	
↓		↓		↓		↓	
☐ Primary Disorder is RESPIRATORY		☐ Primary Disorder is METABOLIC		☐ Primary Disorder is RESPIRATORY		**☐ Primary Disorder is METABOLIC**	
↓				↓			
☐ Reduced HCO_3^- = Uncompensated	☐ Increased HCO_3^- = Compensated	☐ Reduced pCO_2 = Compensated	☐ Elevated pCO_2 = Uncompensated	☐ Reduced HCO_3^- = Compensated	☐ Increased HCO_3^- = Uncompensated	☐ Reduced pCO_2 = Uncompensated	**☐ Elevated pCO_2 = Compensated**
↓		↓		↓		↓	
☐ pCO_2 increased by 10 mm Hg = HCO_3^- increase by 1 mEq	☐ pCO_2 increased by 10 mm Hg = HCO_3^- increase by 4 mEq	☐ $pCO_2 = (1.54*HCO_3^-)+8.36 \pm 1$		☐ pCO_2 decreased by 10 mm Hg = HCO_3^- decrease by 2 mEq		☐ pCO_2> 55	☐ pCO_2< 40
↓	↓	↓	↓	↓		↓	↓
☐ Acute Acidosis	☐ Chronic Acidosis	☐ pCO_2 > predicted	☐ pCO_2 < predicted	☐ Acute alkalosis		☐ Complicating Respiratory Acidosis	☐ Complicating Respiratory Alkalosis
		↓	↓	**☐ pO_2**			
		☐ Complicating Respiratory Acidosis	☐ Complicating Respiratory Alkalosis	**☐ < 80 mm Hg = hypoxemia**		☐ ≥ 80 mm Hg = Adequate Ventilation	
Anion Gap = $[Na^+ - (Cl^- + HCO_3^-)]$							
☐12-14: Normal	☐15-24: Complicating Metabolic Acidosis			☐ > 25: Ketoacidosis, Lactic Acidosis, Salicylate poisoning, Alcohol Poisoning			
DIAGNOSIS/ANALYSIS:Chronic metabolic alkalosis with hypoxemia and respiratory compensation; equivocal pCO_2							

Patient Data -- #8

- This patient presents with the following data:
- pH = 7.25
- pO_2 = 76 mm Hg
- pCO_2 = 50 mm Hg
- HCO_3^- = 22 mEq/L

<table>
<tr><td colspan="10">Arterial Blood Gas Analysis Check-Off Sheet – Patient #8</td></tr>
<tr><td colspan="4"><u>☐ pH< 7.4 = Acidosis</u></td><td colspan="6">☐ pH>7.4 = Alkalosis</td></tr>
<tr><td colspan="2">☐ Normal Range (7.35-7.45)
→ ☐ Chronic</td><td colspan="2"><u>☐ Wildly Off? (< 7.35)
→ ☐ Acute</u></td><td colspan="2">☐ Normal Range (7.35-7.45)
→ ☐ Chronic</td><td colspan="4">☐ Wildly Off? (> 7.45)
→ ☐ Acute</td></tr>
<tr><td colspan="4">↓</td><td colspan="6">↓</td></tr>
<tr><td colspan="2">☐ pCO_2> 40</td><td colspan="2"><u>☐ HCO_3^- < 24</u></td><td colspan="2">☐ pCO_2<40</td><td colspan="4">☐ HCO_3^->24</td></tr>
<tr><td colspan="2">↓</td><td colspan="2">↓</td><td colspan="2">↓</td><td colspan="4">↓</td></tr>
<tr><td colspan="2">☐ Primary Disorder is RESPIRATORY</td><td colspan="2"><u>☐ Primary Disorder is METABOLIC</u></td><td colspan="2">☐ Primary Disorder is RESPIRATORY</td><td colspan="4">☐ Primary Disorder is METABOLIC</td></tr>
<tr><td colspan="4">↓</td><td colspan="6">↓</td></tr>
<tr><td>☐ Reduced HCO_3^- = Uncompensated</td><td>☐ Increased HCO_3^- = Compensated</td><td>☐ Reduced pCO_2 = Compensated</td><td><u>☐ Elevated pCO_2 = Uncompensated</u></td><td>☐ Reduced HCO_3^- = Compensated</td><td colspan="2">☐ Increased HCO_3^- = Uncompensated</td><td colspan="2">☐ Reduced pCO_2 = Uncompensated</td><td>☐ Elevated pCO_2 = Compensated</td></tr>
<tr><td colspan="2">↓</td><td colspan="2">↓</td><td colspan="3">↓</td><td colspan="3">↓</td></tr>
<tr><td>☐ pCO_2 increased by 10 mm Hg = HCO_3^- increase by 1 mEq</td><td>☐ pCO_2 increased by 10 mm Hg = HCO_3^- increase by 4 mEq</td><td colspan="2"><u>☐$pCO_2 = (1.54*HCO_3^-)+8.36 \pm 1$</u>

<u>40-42 mm Hg = predicted</u></td><td colspan="3">☐ pCO_2 decreased by 10 mm Hg = HCO_3^- decrease by 2 mEq</td><td>☐ pCO_2> 55</td><td colspan="2">☐ pCO_2< 40</td></tr>
<tr><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td colspan="3">↓</td><td>↓</td><td colspan="2">↓</td></tr>
<tr><td>☐ Acute Acidosis</td><td>☐ Chronic Acidosis</td><td><u>☐ pCO_2 > predicted</u></td><td>☐ pCO_2 < predicted</td><td colspan="3">☐ Acute alkalosis</td><td>☐ Complicating Respiratory Acidosis</td><td colspan="2">☐ Complicating Respiratory Alkalosis</td></tr>
<tr><td></td><td></td><td>↓</td><td>↓</td><td colspan="6"><u>☐ pO_2</u></td></tr>
<tr><td colspan="2"></td><td><u>☐ Complicating Respiratory Acidosis</u></td><td>☐ Complicating Respiratory Alkalosis</td><td colspan="2"><u>☐ < 80 mm Hg = hypoxemia</u></td><td colspan="4">☐ ≥ 80 mm Hg = Adequate Ventilation</td></tr>
<tr><td colspan="10">Anion Gap = $[Na^+ - (Cl^- + HCO_3^-)]$</td></tr>
<tr><td>☐12-14: Normal</td><td colspan="3">☐15-24: Complicating Metabolic Acidosis</td><td colspan="6">☐ > 25: Ketoacidosis, Lactic Acidosis, Salicylate poisoning, Alcohol Poisoning</td></tr>
<tr><td colspan="10">DIAGNOSIS/ANALYSIS: Acute metabolic acidosis with a complicating respiratory acidosis; give priority to bicarb; hypoxemic; uncompensated</td></tr>
</table>

Patient Data -- #9

- This patient presents with the following data:
- pH = 7.49
- pO_2 = 210 mm Hg
- pCO_2 = 32 mm Hg
- HCO_3^- = 24 mEq/L

Arterial Blood Gas Analysis Check-Off Sheet – Patient #9							
☐ pH< 7.4 = Acidosis				**☐ pH>7.4 = Alkalosis**			
☐ Normal Range (7.35-7.45) → ☐ Chronic		☐ Wildly Off? (< 7.35) → ☐ Acute		☐ Normal Range (7.35-7.45) → ☐ Chronic		**☐ Wildly Off? (> 7.45) → ☐ Acute**	
↓				↓			
☐ pCO_2> 40		☐ HCO_3^- < 24		**☐ pCO_2<40**		☐ HCO_3^- >24	
↓		↓		↓		↓	
☐ Primary Disorder is RESPIRATORY		☐ Primary Disorder is METABOLIC		**☐ Primary Disorder is RESPIRATORY**		☐ Primary Disorder is METABOLIC	
↓				↓			
☐ Reduced HCO_3^- = Uncompensated	☐ Increased HCO_3^- = Compensated	☐ Reduced pCO_2 = Compensated	☐ Elevated pCO_2 = Uncompensated	☐ Reduced HCO_3^- = Compensated	☐ Increased HCO_3^- = Uncompensated	☐ Reduced pCO_2 = Uncompensated	☐ Elevated pCO_2 = Compensated
↓		↓		↓		↓	
☐ pCO_2 increased by 10 mm Hg = HCO_3^- increase by 1 mEq	☐ pCO_2 increased by 10 mm Hg = HCO_3^- increase by 4 mEq	☐ $pCO_2 = (1.54*HCO_3^-)+8.36 \pm 1$		☐ pCO_2 decreased by 10 mm Hg = HCO_3^- decrease by 2 mEq		☐ pCO_2> 55	☐ pCO_2< 40
↓	↓	↓	↓	↓		↓	↓
☐ Acute Acidosis	☐ Chronic Acidosis	☐ pCO_2 > predicted	☐ pCO_2 < predicted	**☐ Acute alkalosis**		☐ Complicating Respiratory Acidosis	☐ Complicating Respiratory Alkalosis
		↓	↓	**☐ pO_2**			
		☐ Complicating Respiratory Acidosis	☐ Complicating Respiratory Alkalosis	☐ < 80 mm Hg = hypoxemia		**☐ ≥ 80 mm Hg = Adequate Ventilation**	
Anion Gap = $[Na^+ - (Cl^- + HCO_3^-)]$							
☐12-14: Normal	☐15-24: Complicating Metabolic Acidosis			☐ > 25: Ketoacidosis, Lactic Acidosis, Salicylate poisoning, Alcohol Poisoning			
DIAGNOSIS/ANALYSIS: Acute respiratory alkalosis, no metabolic compensation; patient is likely hyperventilating.							

Patient Data -- #10

- This patient presents with the following data:
- pH = 7.37
- pO_2 = 88 mm Hg
- pCO_2 = 66 mm Hg
- HCO_3^- = 34 mEq/L

Arterial Blood Gas Analysis Check-Off Sheet – Patient #10							
☐ pH< 7.4 = Acidosis				☐ pH>7.4 = Alkalosis			
☐ Normal Range (7.35-7.45) → ☐ Chronic		☐ Wildly Off? (< 7.35) → ☐ Acute		☐ Normal Range (7.35-7.45) → ☐ Chronic		☐ Wildly Off? (> 7.45) → ☐ Acute	
↓				↓			
☐ pCO_2> 40		☐ HCO_3^- < 24		☐ pCO_2<40		☐ HCO_3^->24	
↓		↓		↓		↓	
☐ Primary Disorder is RESPIRATORY		☐ Primary Disorder is METABOLIC		☐ Primary Disorder is RESPIRATORY		☐ Primary Disorder is METABOLIC	
↓				↓			
☐ Reduced HCO_3^- = Uncompensated	**☐ Increased HCO_3^- = Compensated**	☐ Reduced pCO_2 = Compensated	☐ Elevated pCO_2 = Uncompensated	☐ Reduced HCO_3^- = Compensated	☐ Increased HCO_3^- = Uncompensated	☐ Reduced pCO_2 = Uncompensated	☐ Elevated pCO_2 = Compensated
↓		↓		↓		↓	
☐ pCO_2 increased by 10 mm Hg = HCO_3^- increase by 1 mEq	**☐ pCO_2 increased by 10 mm Hg = HCO_3^- increase by 4 mEq**	☐ $pCO_2 = (1.54*HCO_3^-)+8.36 \pm 1$		☐ pCO_2 decreased by 10 mm Hg = HCO_3^- decrease by 2 mEq		☐ pCO_2> 55	☐ pCO_2< 40
↓	↓	↓	↓	↓		↓	↓
☐ Acute Acidosis	**☐ Chronic Acidosis**	☐ pCO_2 > predicted	☐ pCO_2 < predicted	☐ Acute alkalosis		☐ Complicating Respiratory Acidosis	☐ Complicating Respiratory Alkalosis
		↓	↓	**☐ pO_2**			
		☐ Complicating Respiratory Acidosis	☐ Complicating Respiratory Alkalosis	☐ < 80 mm Hg = hypoxemia		**☐ ≥ 80 mm Hg = Adequate Ventilation**	
Anion Gap = [Na^+ - (Cl^- + HCO_3^-)]							
☐12-14: Normal	☐15-24: Complicating Metabolic Acidosis			☐ > 25: Ketoacidosis, Lactic Acidosis, Salicylate poisoning, Alcohol Poisoning			
DIAGNOSIS/ANALYSIS: Chronic compensated respiratory acidosis; adequate ventilation							

Patient Data -- #11

- This patient presents with the following data:
- pH = 7.12
- pO_2 = 80 mm Hg
- pCO_2 = 70 mm Hg
- HCO_3^- = 22 mEq/L
- Na^+ = 130 mEq/L
- Cl^- = 84 mEq/L
- CO_2 = 24 mEq/L

Arterial Blood Gas Analysis Check-Off Sheet – Patient #11							
☐ pH< 7.4 = Acidosis				☐ pH>7.4 = Alkalosis			
☐ Normal Range (7.35-7.45) → ☐ Chronic		**☐ Wildly Off? (< 7.35) → ☐ Acute**		☐ Normal Range (7.35-7.45) → ☐ Chronic		☐ Wildly Off? (> 7.45) → ☐ Acute	
↓				↓			
☐ pCO_2> 40		**☐ HCO_3^- < 24**		☐ pCO_2<40		☐ HCO_3^->24	
↓		↓		↓		↓	
☐ Primary Disorder is RESPIRATORY		**☐ Primary Disorder is METABOLIC**		☐ Primary Disorder is RESPIRATORY		☐ Primary Disorder is METABOLIC	
↓				↓			
☐ Reduced HCO_3^- = Uncompensated	☐ Increased HCO_3^- = Compensated	☐ Reduced pCO_2 = Compensated	**☐ Elevated pCO_2 = Uncompensated**	☐ Reduced HCO_3^- = Compensated	☐ Increased HCO_3^- = Uncompensated	☐ Reduced pCO_2 = Uncompensated	☐ Elevated pCO_2 = Compensated
↓		↓		↓		↓	
☐ pCO_2 increased by 10 mm Hg = HCO_3^- increase by 1 mEq	☐ pCO_2 increased by 10 mm Hg = HCO_3^- increase by 4 mEq	**☐ $pCO_2 = (1.54*HCO_3^-)+8.36 \pm 1$** **40-42 mm Hg = predicted**		☐ pCO_2 decreased by 10 mm Hg = HCO_3^- decrease by 2 mEq		☐ pCO_2> 55	☐ pCO_2< 40
↓	↓	↓	↓	↓		↓	↓
☐ Acute Acidosis	☐ Chronic Acidosis	**☐ pCO_2 > predicted**	☐ pCO_2 < predicted	☐ Acute alkalosis		☐ Complicating Respiratory Acidosis	☐ Complicating Respiratory Alkalosis
		↓	↓	☐ **pO_2**			
		☐ Complicating Respiratory Acidosis	☐ Complicating Respiratory Alkalosis	☐ < 80 mm Hg = hypoxemia		**☐ ≥ 80 mm Hg = Adequate Ventilation**	
Anion Gap = [Na^+ - (Cl^- + HCO_3^-)]							
☐12-14: Normal	**☐15-24: Complicating Metabolic Acidosis**			☐ > 25: Ketoacidosis, Lactic Acidosis, Salicylate poisoning, Alcohol Poisoning			
DIAGNOSIS/ANALYSIS: Anion gap = 22; uncompensated metabolic acidosis with complicating respiratory acidosis; adequate ventilation							

Patient Data -- #12

- This patient presents with the following data:
- pH = 7.52
- pO_2 = 60 mm Hg
- pCO_2 = 50 mm Hg
- HCO_3^- = 32 mEq/L

<table>
<tr><td colspan="8">Arterial Blood Gas Analysis Check-Off Sheet – Patient #12</td></tr>
<tr><td colspan="4">☐ pH< 7.4 = Acidosis</td><td colspan="4">☐ pH>7.4 = Alkalosis</td></tr>
<tr><td colspan="2">☐ Normal Range (7.35-7.45)
→ ☐ Chronic</td><td colspan="2">☐ Wildly Off? (< 7.35)
→ ☐ Acute</td><td colspan="2">☐ Normal Range (7.35-7.45)
→ ☐ Chronic</td><td colspan="2">☐ Wildly Off? (> 7.45)
→ ☐ Acute</td></tr>
<tr><td colspan="4">↓</td><td colspan="4">↓</td></tr>
<tr><td colspan="2">☐ pCO_2> 40</td><td colspan="2">☐ HCO_3^- < 24</td><td colspan="2">☐ pCO_2<40</td><td colspan="2">☐ HCO_3^->24</td></tr>
<tr><td colspan="2">↓</td><td colspan="2">↓</td><td colspan="2">↓</td><td colspan="2">↓</td></tr>
<tr><td colspan="2">☐ Primary Disorder is RESPIRATORY</td><td colspan="2">☐ Primary Disorder is METABOLIC</td><td colspan="2">☐ Primary Disorder is RESPIRATORY</td><td colspan="2">☐ Primary Disorder is METABOLIC</td></tr>
<tr><td colspan="4">↓</td><td colspan="4">↓</td></tr>
<tr><td>☐ Reduced HCO_3^- = Uncompensated</td><td>☐ Increased HCO_3^- = Compensated</td><td>☐ Reduced pCO_2 = Compensated</td><td>☐ Elevated pCO_2 = Uncompensated</td><td>☐ Reduced HCO_3^- = Compensated</td><td>☐ Increased HCO_3^- = Uncompensated</td><td>☐ Reduced pCO_2 = Uncompensated</td><td>☐ Elevated pCO_2 = Compensated</td></tr>
<tr><td colspan="2">↓</td><td colspan="2">↓</td><td colspan="2">↓</td><td colspan="2">↓</td></tr>
<tr><td>☐ pCO_2 increased by 10 mm Hg = HCO_3^- increase by 1 mEq</td><td>☐ pCO_2 increased by 10 mm Hg = HCO_3^- increase by 4 mEq</td><td colspan="2">☐ $pCO_2 = (1.54*HCO_3^-)+8.36\pm 1$</td><td colspan="2">☐ pCO_2 decreased by 10 mm Hg = HCO_3^- decrease by 2 mEq</td><td>☐ pCO_2> 55</td><td>☐ pCO_2< 40</td></tr>
<tr><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td colspan="2">↓</td><td>↓</td><td>↓</td></tr>
<tr><td>☐ Acute Acidosis</td><td>☐ Chronic Acidosis</td><td>☐ pCO_2 > predicted</td><td>☐ pCO_2 < predicted</td><td colspan="2">☐ Acute alkalosis</td><td>☐ Complicating Respiratory Acidosis</td><td>☐ Complicating Respiratory Alkalosis</td></tr>
<tr><td></td><td></td><td>↓</td><td>↓</td><td colspan="4">☐ pO_2</td></tr>
<tr><td colspan="2"></td><td>☐ Complicating Respiratory Acidosis</td><td>☐ Complicating Respiratory Alkalosis</td><td colspan="2">☐ < 80 mm Hg = hypoxemia</td><td colspan="2">☐ ≥ 80 mm Hg = Adequate Ventilation</td></tr>
<tr><td colspan="8">Anion Gap = $[Na^+ - (Cl^- + HCO_3^-)]$</td></tr>
<tr><td>☐12-14: Normal</td><td colspan="3">☐15-24: Complicating Metabolic Acidosis</td><td colspan="4">☐ > 25: Ketoacidosis, Lactic Acidosis, Salicylate poisoning, Alcohol Poisoning</td></tr>
<tr><td colspan="8">DIAGNOSIS/ANALYSIS: equivocal pCO_2; acute metabolic alkalosis with incomplete respiratory compensation</td></tr>
</table>

Common Mixed Gas States

These “add onto” the change in pH and make all bets off and no gases text-book ☺

Mixed State -- #1

State	Metabolic acidosis
Plus	Respiratory acidosis (etiology: COPD going into shock)
Characteristics/Lab Data	> $\uparrow pCO_2$, $\downarrow HCO_3^-$, >$\downarrow$ pH
E.g.'s	Chronic renal failure with elevated fluid volume ("pizza binge", pulmonary edema, DKA with narcotics/barbiturates

Mixed State -- #2

State	Metabolic alkalosis
Plus	Respiratory alkalosis (etiology: overventilated COPD)
Characteristics/Lab Data	$>\downarrow pCO_2$, $\uparrow HCO_3^-$, $>\uparrow$ pH
E.g.'s	Hyperventilating patient with CHF or hepatic cirrhosis with vomiting or head trauma with hyperventilation, therapy with diuretics

Mixed State -- #3

State	Metabolic acidosis
Plus	Respiratory alkalosis
Characteristics/Lab Data	$\downarrow HCO_3^-$, $\downarrow pCO_2$ (drops in HCO_3^- and pCO_2 are greater than expected), normal pH
E.g.'s	Lactic acidosis, complicating septic shock, salicylate intoxication;

Mixed State -- #4

State	Metabolic alkalosis
Plus	Respiratory acidosis
Characteristics/Lab Data	↑ pCO_2, ↑ HCO_3^-, pH is about normal
E.g.'s	COPD tx with diuretics, NG suction, steroids, elevated dietary Cl^-, KCl therapy that leads to ↓pH and breathing