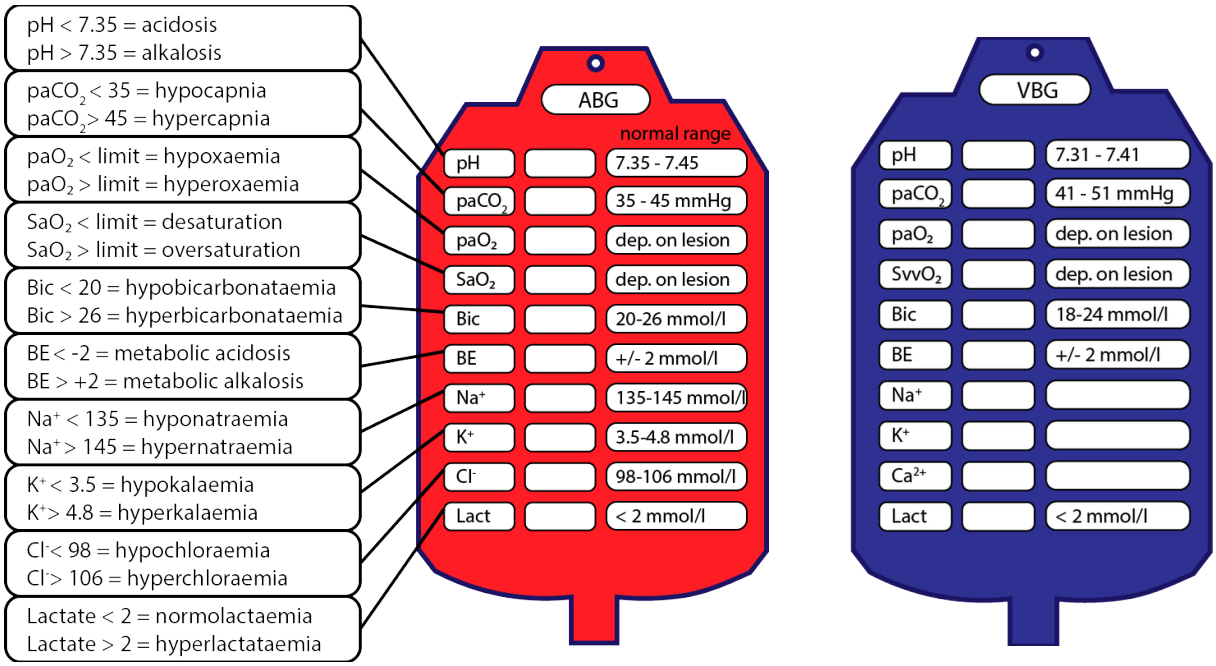
A PRAGMATIC APPROACH TO BLOOD GASES

There is an immense body of literature that you can indulge in to gain in-depth knowledge about blood gases, acid-base physiology and interpretation. The goal of this page is to have a hands-on, easy approach to ABGs and VBGs for the daily use in PICU.

NORMAL BLOOD GAS VALUES



HOW TO APPROACH A GAS

pH

Define whether your patient is acidotic or alkalotic by looking at the pH

pH is determined by 3 factors
- paCO2
- Strong Ion Difference (SID)
- Weak Bases

CO2

Is your your paCO2 low or high?
The pH acutely changes by 0.08 for every 10mHg difference in CO2 fro m 40mmHg. Hypercarbia causes acidosis and hypocarbia alkalosis. Chronic changes are compensated differently and explained below

Examples:
If paCO2 50 --> pH 7.32
If paCO2 30 --> pH 7.48

BE

Is your base excess negative or positive?
Negative --> Acidosis
Positive --> Alkalosis

BE describes the amount of acid or base you need to add to a sample in order for it to reach a pH of 7.40.

A negative BE signifies metabolic acidosis which can be either NAGMA or HAGMA

NAGMA = Non-Anion-Gap Metabolic Acidosis

Neg

HAGMA = High Anion-Gap Metabolic Acidosis

NAGMA

NAGMA is due to changes in the Strong Ion Difference (SID) which is roughly the difference between your Sodium and Chloride. The normal SID is 38.
An SID < 38 causes metabolic acidosis which is the SAME as relative hyperchloraemic acidosis.
The difference in SID to its normal value (38) determines the amount the NAGMA contributing to the BE

It is NOT the absolute chloride value that causes acidosis but the difference between Na and Cl! Examples:

Na 140 / Cl 102
--> SID 38 --> No NAGMA

Na 140 / Cl 110
--> SID 30 --> NAGMA of 8 mmol/l

HAGMA

HAGMA is due to excess acids with an elevated anion gap (AG). Calculate: Na+K-Cl-Bic (Normal < 12).
An AG > 12 can be due to multiple chemical compounds of which Lactate, Urea and Ketones are the most commonly encountered in PICU. An AG > 12 (HAGMA) contributes to your BE just the way NAGMA does. Remember the differential using "MUDPILES".

M - Metformin, Metabolic
U - Urea
D - Diabetes (Ketones)
P - Pyrazinamide (Tuberculostatic)
I - Isoniazide (Antimicrobial)
L - Lactate
E - Ethanol, Methanol, ...
S - Salicylates (Aspirin)

CHyper

Chronic hyperventilation with chronic hypocarbia causes a compensatory decrease in bicarbonate.
Chronic hyperventilation is rare and limited a certain extent. The bicarbonate usually does not reach values below 18mmol/l

For every decrease in paCO2 by 10mmol/l < 40mmol/l the kidneys will dump bicarbonate

- Acutely: 2mmol/l
- Chronically: 5mmol/l

Pos

A positive BE signifies metabolic alkalosis due to excess base which is due to either contraction alkalosis (relative hypochloraemia = increased SID > 38) or an increase in bicarbonate due to other causes (compensation for hypercapnia, NaBic administration, frusemide...)

CHypo

Chronic hypoventilation with chronic hypercarbia causes a compensatory increase in bicarbonate to normalise pH.

For every increase in paCO2 by 10mmol/l > 40mmol/l the kidneys will retain bicarbonate

- Acutely: 1mmol/l
- Chronically: 4mmol/l

ContrAlk

Contraction alkalosis or relative hypochloraemic metabolic alkalosis is caused by relative lack of chloride in relation to sodium. Calculate the SID (Na-Cl)

Again, the difference between Na and Cl defines the change in BE! Example:
(pyloric stenosis --> vomiting --> loss of gastric acid (HCl) -->
Na 135 / Cl 90 --> SID 45 --> adds 7 to the BE (delta SID = 45-38 = 7)

SaO2

The SaO2 is the most accurate saturation measurement you will get in your critically ill patient. The target range depends on the underlying pathology. There can be considerable discrepancy between SpO2 and SaO2.

SaO2 is crucial to Oxygen Delivery!

Lactate

An increase in lactate > 2mmol/l in PICU is quite common and associated with increased mortality. The differential includes insufficient oxygen delivery with anaerobic metabolism, inborn errors of metabolism or iatrogenic causes such as Hartmann's, PD fluid or beta2-agonists.

Lactate levels add 1:1 to the acidosis reflected in the base excess.

THE BOSTON RULES

RULES FOR RESPIRATORY DISORDERS

1 ACUTE RESPIRATORY ACIDOSIS

The [HCO3] will increase by 1 mmol/l for every 10 mmHg elevation in pCO2 above 40 mmHg.

$$Expected\ [HCO_3^-] = 24 + \left(\frac{pCO2 - 40}{10}\right)$$

2 CHRONIC RESPIRATORY ACIDOSIS

The [HCO3] will increase by 4 mmol/l for every 10 mmHg elevation in pCO2 above 40mmHg.

$$Expected\ [HCO_3^-] = 24 + 4\left(\frac{pCO2 - 40}{10}\right)$$

3 ACUTE RESPIRATORY ALKALOSIS

The [HCO3] will decrease by 2 mmol/l for every 10 mmHg decrease in pCO2 below 40 mmHg.

$$Expected\ [HCO_3^-] = 24 - 2\left(\frac{40 - pCO2}{10}\right)$$

4 CHRONIC RESPIRATORY ALKALOSIS

The [HCO3] will decrease by 5 mmol/l for every 10 mmHg decrease in pCO2 below 40 mmHg.

$$Expected\ [HCO_3^-] = 24 - 5\left(\frac{40 - pCO2}{10}\right)$$

RULES FOR METABOLIC DISORDERS

5 METABOLIC ACIDOSIS

The expected pCO2 (in mmHg) for any given BE is calculated from the following formula (Winter's formula):

$$Expected\ [pCO2] = 1.5\ \times [HCO_3^-] + 8\ (Range \pm 2)$$

5 METABOLIC ALKALOSIS

The expected pCO2 (in mmHg) for any given BE is calculated from the following formula:

$$Expected\ [pCO2] = 0.7\ \times [HCO_3^-] + 20\ (Range \pm 5)$$

CORRECTION FOR ALBUMIN

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Many PICU patients have lower than normal albumin levels. This effects the blood gas results!

Hypoalbuminaemia makes your gases look falsely good. With low albumin levels your BE on the gas appears less negative than what it actually is. Use the following formula to correct for this phenomenon.

$$Corrected\ [BE] = BE + \frac{(Albumin - 40)}{4}$$