Interpreting Neonatal Blood Gases

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Introduction

- Disturbances of acid base balance can be more hazardous than the primary disease
- Whatever happens inside the body is controlled by enzymes
- These are affected by environmental changes
- Acidity and Alkalinity

- An acid base disturbance is not a disease but rather a symptom of an underlying health problem that has not been properly corrected by the body's normal compensatory mechanism
- An ↑in hydrogen ions makes a solution more acidic
- A ↓ in hydrogen ions makes a solution more alkalotic
- The symbol pH – power of hydrogen
- Kidneys can excrete hydrogen ions and also conserve bicarbonate

Blood Gas Values

- When considering blood gases five values are usually measured
- pH 7.25 – 7.45 gestational dependent
- p02 - 50 – 90 gestational dependent
- paC02 – 40-55 mmHg
- HC03 – 22-26 mEq/L
- BE -2 - +2 mEq/L
- 02 Saturations – according to gestation and clinical condition

Terminology

- Acid – donator of hydrogen ions
- Base – acceptor of hydrogen ions
- Buffer – weak acid and strong base pair that accepts or donates H+ to maintain a balanced pH
- pH – negative logarithm of H+ concentration
- ↑ H+ - pH more acidic
- ↓ H+ - pH more alkaline

- Acidemia – blood pH below 7.25
- Alkalemia – blood pH above 7.45
- Acidosis – Process caused by acidemia
- Alkalosis – Process cause by alkalemia
- H+ - Hydrogen ion
- H2C03 – Carbonic Acid
- HC03 - Bicarbonate

Renal responses to Acid Base Imbalance

- Metabolic acidosis – phosphate and ammonia buffers used to increase H+ excretion

- Respiratory Acidosis – increased H+ excretion, increased HC03 -resorption

- Metabolic alkalosis
  - (a) decreased $HC0_3$ reclamation from the urine
  - (b) decreased H+ excretion if normal serum Na+ and K+
  - (c) if hyponatremia, Na+ is reabsorbed requiring H+ excretion and $HC0_3$ retention
  - (d) if hypokalemia is present, K+ is reabsorbed in place of H+
- Respiratory alkalosis – decreased H+ excretion and $HC0_3$ resorption as with metabolic acidosis

- Lower pH indicates a higher concentration of hydrogen ions
- Higher pH indicates a lower concentration of hydrogen ions
- To maintain an acid base balance the body has 3 lines of defence
- Bicarbonate can combine with C02 to form carbonic acid
- The rate of removal of carbonic acid can be adjusted by altering the ventilation

Respiratory Component

- Majority of acids formed come from interaction of $C0_2$ and H_20
- Once produced by cells $C0_2$ diffuses into the plasma
- 5% of $C0_2$ travels dissolved in plasma
- 95% transported within the RBC

- 1/3rd forms carbonic compounds
- The remaining 2/3rd is acted by carbonic anhydrase
- Carbonic acid will then break down to release H+ and $HC0_3$
- $C0_2 + H_20 = H_2C0_3 = H+ + HC0_3$

- pH changes caused by changes in pC02 are termed *respiratory*
- Hyperventilation equals formation of less carbonic acid, ↑pH
- Hypoventilation opposite effect
- Remember the concentration of $C0_2$, $HC0_3$ and H+ moves in the opposite direction from the pH
- ↑$pC0_2$ → ↑H_2C0_3 → ↑H+ ↓pH
- ↓pC02 → ↓H_2C0_3 → ↓H+ ↑pH

Metabolic Component

- Metabolic acids are released in the circulatory system from 3 major sources
- Amino acids
- Lactic acids
- Keto acids

- Kidneys are most important in regulating metabolic acidosis and also responsible for maintaining the plasma levels of bicarbonate
- pH changes that occur because of changes in $HC0_3$ concentrations are termed *metabolic*

- Kidney excretion of H+
- Reabsorption of filtered $HC0_3$
- Excretion of acids
- Formation of ammonia
- $\uparrow HC0_3 \rightarrow \uparrow$ pH
- $\downarrow HC0_3 \rightarrow \downarrow$ pH

The Buffer System

- Three major systems are
- Plasma proteins
- Hb - $HC0_3$ ions are from the hydroxylation of $C0_2$ by H_20 inside the RBC's
- HCO_3 - most important regulated by the kidneys

Compensation

- A 1:20 acid base ratio is needed to maintain a pH within normal range
- 1 part carbonic and 20 parts bicarbonate
- Correction occurs by altering the component responsible for the abnormality

- Compensation occurs when the body normalises the pH
- Other ways to normalise pH
  - Alteration in minute ventilation – regulate $C0_2$ levels
  - Kidneys – retain or excrete $HC0_3$ in response to the changes in pH
  - Kidneys also can excrete H+ in combination with phosphate and ammonia
- Renal – respiratory acidosis H+ excretion, increased $HC0_3$ reabsorption, met acidosis,phosphate and ammonia buffers used to ↑ H+ excretion

Interpretation of Blood Gases

- Five values need to be considered in evaluating blood gases:
  - pH
  - Partial pressure of oxygen -
  - Partial pressure of carbon dioxide
  - Standard bicarbonate
  - Base excess

- pH – measure of hydrogen ion concentration in the blood and indicates acidity or alkalinity
- $p0_2$ - measure of partial pressure of oxygen dissolved in the blood
- $pC0_2$ - measure of partial pressure of carbon dioxide dissolved in the blood
- $HC0_3$ - measure amount of bicarbonate in the blood
- BE - indicates the amount of buffering agents available to mop up hydrogen ions

Errors that can occur

- Temperature can alter a true arterial gas as the blood gas machine report results for 37°C
- Oxygen saturations are based on adult Hb not foetal or mixed Hb
- Heparin can lower $pC0_2$ and will increase base deficit without altering the pH
- Air bubbles will decrease $pC0_2$ and increase $p0_2$

Metabolic Acidosis

- Signs
  - Fall in pH (increased H+)
  - Normal or low $pC0_2$
  - Normal or low $p0_2$ (arterial gas)
  - Negative base excess (buffering agents are being used)

Taking Blood Gases - Sites

- Arterial site – arterial specimens, either from an indwelling arterial line or peripheral arterial stab, are required to assess $p0_2$
- Venous site – more accurate from the umbilical vein catheter or venous site
- Capillary site – these are the least useful, particularly if there is decrease perfusion or the feet are cold

Causes of Metabolic acidosis

- Accumulation of acids (hypoxia)
- Infusion of acid 9 TPN)
- Hypoglycaemia
- Hypothermia
- Metabolic disorders
- Hypovolaemia
- Infection
- Renal immaturity in premature infants

Treatment

- Treat the cause
- Oxygen may be needed to be increased (hypoxia)
- TPN may need to be ceased
- Use of sodium bicarbonate can lead to metabolic alkalosis and IVH – use with caution
- Half correction is usually used

Metabolic Alkalosis

- Sign
  - Increase in pH
  - Normal $pC0_2$ and $p0_2$
  - Increase in bicarbonate
- Causes
  - Usually caused by inappropriate dose of sodium bicarbonate
  - Vomiting and constant suctioning of the gastric acid
  - Kidney will generate bicarb in response to a low K
- Treatment
  - Treat the underlying cause

Respiratory Acidosis

- Frequently see in respiratory distress syndrome and perinatal hypoxia
- Due to poor gas exchange
- Signs
  - A fall in pH
  - An increase in $pC0_2$
  - BE and $HC0_3$ may be normal

Respiratory Acidosis

- It is usually necessary to commence respiratory support (Intubation, CPAP or HHF)
- Rate may need to be increase
- PIP may need to be increased
- PEEP may need to be decreased
- Longer expiratory time can allow $C0_2$ to be exhaled more efficiently

Respiratory Alkalosis

- Excessive mechanical ventilation is the most common cause, which allows excessive elimination of $C0_2$
- Note – $C0_2$ which is very low can lead to a fall in cardiac and cerebral blood flow
- Signs
  - An increase in pH
  - A decrease in $pC0_2$
- Treat
  - Wean the PIP or tidal volume then respiratory rate

Mixed Acidosis

- Usually caused by poor gas exchange leading to anaerboic metabolism and an excess production of hydrogen ions
- Signs
  - Low pH due to general acidosis
  - Increase in $pC0_2$ because of poor gas exchange
  - Low $p0_2$ - poor gas exchange
  - HC03 used up to try and buffer the acid
  - Low BE because the buffer is being used up

Mixed Acidosis

- Treatment
  - If gas exchange is improved then respiratory acidosis will be corrected
  - Correction of the respiratory acidosis may also help correct the metabolic acidosis
  - Sodium bicarbonate may be needed if the metabolic acidosis is severe

Compensation

- A disturbance in the acid/base balance
- Degrees of compensation
  - Uncompensated – pH is abnormal & one of the acid base components is abnormal and one normal
  - Partially compensated – 2 acid base components are abnormal in opposite directions
  - Fully compensated – pH reaches normal range

Compensated Metabolic Alkalosis

- Caused by an accumulation of bicarbonate
- Body will attempt to retain $C0_2$ to compensate
- Can result in hypoventilation
- pH will be normal
- $pC0_2$ and $HC0_3$ will be raised

Compensated Metabolic Acidosis

- Caused by an accumulation of hydrogen ions
- Body will try to lower carbonic acid levels to compensate which will result in hyperventilation
- pH will be near normal
- $pC0_2$ and $HC0_3$ will be low

Compensated Respiratory Alkalosis

- Caused by hyperventilation causing a low pC02
- Renal excretion of bicarbonate will be increased to help restore acid/bicarbonate to normal
- pH will be normal
- $pC0_2$ and $HC0_3$ will be low

Compensated Respiratory Acidosis

- Often found in chronic lung disease with a persistent increase in pC02 and a decrease in renal excretion of bicarbonate
- pH will be normal
- $pC0_2$ and $HC0_3$ will be raised