Acid Base Status

Acid Base Status is assessed in patients with respiratory symptoms (shortness of breath, change in respiratory rate) but also in the unconscious patient and those with abnormal electrolytes where the total bicarbonate is noted to be significantly raised or reduced. Acid base status should also be assessed when blood glucose levels are found to be very high (diabetic ketoacidosis).

The routine parameters included in blood gas analysis are:

- pH, hydrogen ion concentration
- pCO2, the partial pressure of carbon dioxide
- pO2, the partial pressure of oxygen
- actual bicarbonate concentration
- base excess: the amount of acid (or base) required to titrate 1L of blood back to "standard" conditions (pH 7.4, pCO2 5.33kPa at 37°C).

Some analysers will also provide electrolyte, glucose and lactate results, co-oximetry and a large number of calculated parameters indicating the effectiveness of gas transfer and oxygenation of the tissues.

Pseudonyms: Blood Gas Analysis

General information

Collection Container: Blood gas collection kits should be available for adults and children. Dedicated heparinised syringes or capillaries are required to prevent clotting of the samples and avoid introduction of air bubbles.

See page 9 of the guide on capillary sampling in paediatrics for details:
http://staffnet.cmft.nhs.uk/policies/paediatrics/capillary%20blood%20sampling%20for%20children%20v1%20final%20formatted.pdf

For reliable results it is imperative that the samples are thoroughly mixed, the device must be completely filled.

Type and volume of sample: Arterial samples are preferred as venous samples will not accurately reflect the oxygenation status of the patient. Capillary samples are NOT advised for pO2 measurement.

Specimen transport/special precautions: "code blue" – must be received in the lab within 30 minutes, do not send in the pneumatic tube (pod). Needles must be removed and discarded safely before the clearly labelled samples are sent to the lab on ice.

Point of Care blood gas analysers are present in some wards but must NOT be used without prior training. Please note the plastic capillary sampling devices have reduced sample stability compared to glass tubes and MUST be analysed on a blood gas analyser on the wards.

https://intranet.mft.nhs.uk/content/hospitals-mcs/clinical-scientific-services/laboratory-medicine/point-of-care-testing

Laboratory information

Method principle: A specific and selective electrode is required for each parameter reported. In general, a change in electric current of voltage is generated based on the level of hydrogen ion (for pH), oxygen or carbon dioxide present. Actual bicarbonate is a calculated value using the values determined for the other tests.

Biological Reference Ranges:

pH: 0-28d: 7.18-7.51 1-5 months: 7.18-7.50 6-11 months: 7.27-7.49 >=12 months to 17 years: 7.35-7.45
pCO2: Newborn (0-28d): 3.6-5.3 Infant (1-11 months): 3.6-5.5 >=12 months to 17 years: 4.3-6.4 >18 years: Male 4.67 – 6.4kPa; Female 4.27 – 6.0kPa
pO2: 1-24h: 7.3-10.6 kPa 24-48h: 7.2-12.6 kPa All other ages: 11.1 – 14.4 kPa arterial 12.0-14.7 kPa capillary 6.7 - 10.7 kPa
Actual bicarbonate: 22 - 29 mmol/L
Base Excess Newborn-10 to -2 mmol/L Infant -7 to -1 mmol/L Child -4 to +2 mmol/L male -2.3 to + 2.3 mmol/L female -3.0 to + 1.6 mmol/L

Turnaround times: Due to the unstable nature of the samples, results should be available within 2h of receipt in the lab. Please note samples in plastic capillary devices can no longer be analysed in the central laboratory.

Clinical information

The basis of determining acid-base status is the Henderson-Hasselbach Equation:

pH = pK + log (bicarbonate concentration/pCO2)

pK is the dissociation constant of water in plasma, 6.105

So if there are disturbances in the processes for removing excess acid (decreased expiration of CO_2 or decline in renal function (reduced excretion of hydrogen ions) then pH falls and the patient becomes acidotic. The cause is described as respiratory or metabolic depending on whether pCO_2 is increased or bicarbonate is decreased.

The converse scenario is an alkalosis, decrease in pCO_2, increase in bicarbonate and pH rises.
The cause can be respiratory or metabolic and in either disturbance (acidosis or alkalosis) the compensatory mechanism is opposite to the cause i.e. a respiratory acidosis will be compensated for by a metabolic alkalosis but the body will never over-compensate. This can take up to 24h.

https://acutecaretesting.org/en/articles/an-introduction-to-acidbase-balance-in-health-anddisease

Factors known to significantly affect the results:

Poor mixing will result in a clotted sample which is unsuitable for analysis.

Air bubbles will elevate the pO_2

Delayed analysis will underestimate the pO_2 and bicarbonate.

All samples are assumed to be from a patient with body temperature 37°C. Results will be obtained which are significantly outside the reference ranges when a patient is extremely pyrexial or hypothermic. This is not necessarily pathological as the results will normalise as the body temperature returns to the normal range.

pH tends to increase as temperature falls, pCO_2 and pO_2 decrease.

Clinical decision points:

This is entirely dependent on the clinical scenario and the previous medical history of the patient, e.g. patients with longstanding COPD may have stable bicarbonate or pCO_2 levels which are above the age-related reference range. Local protocols should be consulted. Blood gas analysis may be used to determine whether a patient requires home oxygen for example.

(Last updated May 2019)