ARterial Blood Gas Analysis 1: Understanding ABG Reports

LEARNING OBJECTIVES
1. Describe the components of an ABG report and their ‘normal’ parameters.
2. Perform a basic analysis of an ABG with only one obvious abnormal parameter, that is, one without evident compensation.

ph and hydrogen ion (H⁺) activity
The pH scale ranges from 1–14, where 1 is the strongest acid, 14 is the strongest alkali and 7 is neutral. Although the pH may vary slightly within a range and still be considered normal, for the purpose of ABG analysis 7.4 is considered the absolute norm (Pagana and Pagana, 2006). This reading is slightly alkalotic.

The pH of a solution gives information on the potential for it to become hydrogen. When acids are dissolved in water they release free hydrogen ions (H⁺). The concentration of H⁺ is far greater in an acid than it is in an alkali and, obviously, the stronger the acid, the more H⁺ it contains. It is therefore slightly confusing that something with a high potential to become hydrogen has a small number on the pH scale. The reason for this is that the scale is a negative logarithm designed to help understanding of very small numbers with many decimal places. A pH of 1 means that the concentration of H⁺ in that solution is 0.1. A pH of six denotes that the concentration of H⁺ in that solution is 0.000001 and a pH of 14 denotes an H⁺ concentration of 0.00000000000001. It would be impractical to keep writing down all these decimal places, so we tend to refer to the number of zeros as the pH.

For every decrease in the pH by 1, there is a tenfold increase in the number of hydrogen ions. Small changes in pH can create huge problems within the body.

\[ \text{PaCO}_2 \]
This is the partial pressure of carbon dioxide dissolved within the arterial blood. It is used to assess the effectiveness of ventilation.

Critically ill patients are not confined to critical care units. Every day, practitioners working in acute areas encounter arterial blood gas (ABG) results, which they may not necessarily be able to interpret. It can be difficult to find time to develop knowledge. However, in light of guidance and policy documents (NICE, 2007; Department of Health, 2000), it is imperative that all nurses working in acute areas can interpret ABGs and ensure patients receive timely and appropriate care.

WHAT IS AN ABG?
For analysis a small sample of arterial blood (approximately 2ml) is taken from an arterial sampling device (arterial line) situated in an artery, or taken via an intermittent ‘stab’ into an artery. The former method is better for patients if frequent samples are required as it reduces pain and the risk of damage to the artery.

An ABG is typically requested to determine the pH of the blood and the partial pressures of carbon dioxide (PaCO₂) and oxygen (PaO₂) within it. It is used to assess the effectiveness of gaseous exchange and ventilation, be it spontaneous or mechanical. If the pH becomes deranged, normal cell metabolism is affected. The ABG allows patients’ metabolic status to be assessed, giving an indication of how they are coping with their illness. It would therefore seem logical to request an ABG on any patient who is or has the potential to become critically ill. This includes patients in critical care areas and those on wards who ‘trigger’ early-warning scoring systems. Others who give cause for concern are patients with acute illnesses or exacerbations of conditions and those in the peri-operative and peri-arrest periods.

TRANSFERRING THE SAMPLE TO THE ANALYSER
In order for the sample to be accurate, it should be analysed within 10 minutes of sampling from the patient (Cornock, 1996). To prevent haemolysis it should be handled gently, avoiding any vigorous shaking. Providing constant agitation by rolling the syringe gently will also prevent plasma separation.

Patient details and percentage of oxygen being administered must be entered along with their identification number. Some machines request patients’ core temperature as it is known to affect the gases dissolved within the plasma, and result in a more accurate reading. However, Woodrow (2004) pointed out that temperature probes can be inaccurate and so entering a temperature of 37°C for all patients would be better practice.

INFORMATION PROVIDED BY AN ABG
Depending on the type of analyser, nurses may receive some or all of the following information, outlined below.

\[ \text{pH} \]
The pH scale ranges from 1–14, where 1 is the strongest acid, 14 is the strongest alkali and 7 is neutral. Although the pH may vary slightly within a range and still be considered normal, for the purpose of ABG analysis 7.4 is considered the absolute norm (Pagana and Pagana, 2006). This reading is slightly alkalotic.

The pH of a solution gives information on the potential for it to become hydrogen. When acids are dissolved in water they release free hydrogen ions (H⁺). The concentration of H⁺ is far greater in an acid than it is in an alkali and, obviously, the stronger the acid, the more H⁺ it contains. It is therefore slightly confusing that something with a high potential to become hydrogen has a small number on the pH scale. The reason for this is that the scale is a negative logarithm designed to help understanding of very small numbers with many decimal places. A pH of 1 means that the concentration of H⁺ in that solution is 0.1. A pH of six denotes that the concentration of H⁺ in that solution is 0.000001 and a pH of 14 denotes an H⁺ concentration of 0.00000000000001. It would be impractical to keep writing down all these decimal places, so we tend to refer to the number of zeros as the pH.

For every decrease in the pH by 1, there is a tenfold increase in the number of hydrogen ions. Small changes in pH can create huge problems within the body.

\[ \text{PaCO}_2 \]
This is the partial pressure of carbon dioxide dissolved within the arterial blood. It is used to assess the effectiveness of ventilation.

\[ \text{PaO}_2 \]
This is the partial pressure of oxygen dissolved within the arterial blood. It is used to assess the effectiveness of ventilation.

\[ \text{HCO}_3^- \]
This is the concentration of bicarbonate ions within the arterial blood. It is used to assess the effectiveness of ventilation.

\[ \text{BE} \]
This is the base excess of the arterial blood. It is used to assess the effectiveness of ventilation.

\[ \text{pCO}_2 \]
This is the partial pressure of carbon dioxide within the arterial blood. It is used to assess the effectiveness of ventilation.
The normal range for a healthy person is 4–6kPa, although in chronic pulmonary diseases it may be considerably higher and still normal for that patient.

**PaO₂**
This is the partial pressure of oxygen dissolved within the arterial blood and will determine oxygen binding to haemoglobin (SaO₂). It is of vital importance but is not used in determining patients’ acid base status.

The normal range for a healthy person is approximately 10 less than the percentage of oxygen breathed in. For example, we breathe in air, which at sea level contains 21% oxygen, thus the expected SaO₂ should be at least 11kPa.

Levels that are higher than normal are usually associated with unnecessarily high levels of supplementary oxygen, while low readings indicate hypoxaemia (Simpson, 2004).

**SaO₂**
The arterial saturation depends on the PaO₂ but also the haemoglobin (Hb). Although similar to SpO₂ (measured by a pulse oximeter), it is more accurate. The normal levels are 97% and above, although levels above 90% are often acceptable in critically ill patients.

**HCO₃⁻ or SBC**
HCO₃⁻ is the chemical formula for bicarbonate, an alkali. It is the main chemical buffer in plasma and alludes to the body’s metabolic status. It is not directly measured but calculated from other values such as the PaCO₂, haemoglobin (Hb) and pH using complicated formulas. Some analysts use the standard bicarbonate measurement (SBC). Again this is not measured but is calculated and slightly more accurate than HCO₃⁻ as it takes into account bicarbonate produced as a result of respiratory failure (Simpson, 2004).

Several textbooks publish many different normal ranges for HCO₃⁻. It is easy to remember the normal range as being in the 20s (mmol/l). If the HCO₃⁻ is in the low 20s it might be heading out of range, and if it is in the high 20s this also indicates it is heading out of range. The ideal number would be somewhere in the middle, such as 24, 25 or 26mmol/l.

**Base excess (BE)**
For many practitioners this is perhaps the most confusing element of the ABG report. Base excess is a surplus amount of base (alkali) within the blood. However, it can be normal to have a small amount of surplus within the blood. When there is no surplus base within the blood, rather confusingly it is reported as a negative base excess. However, this too can be normal. The normal range can be anywhere on the linear scale between –2mmol and +2mmol per litre of blood.

The concept of negative base excess can be explained as follows – imagine there is a conical flask within the body and it stores ‘base’ in case the body might need it. If, for example, the pH falls and the blood becomes acidic, the body will draw on this base, pulling it out of storage and using it to ‘mop up’ the acid. The body now has none in storage, that is, a negative base excess exists.

If the base excess were reported as +1mmol, this means that in theory 1mmol of base needs to be removed per litre of blood to return the pH to 7.4. Conversely, a base excess of –1mmol means that the blood would have a pH of 7.4 if an extra 1mmol of base were added to each litre of blood.

Nurses who find it difficult to understand the concept of double negatives may prefer to use the normal bicarbonate range when analysing ABGs and refer to the BE as a quality control measure. This is because HCO₃⁻ and BE work in harmony – they are effectively measuring the same thing. If the HCO₃⁻ is out of range and reading high, the BE will also be out of range and reading high (in this case a positive number, greater than 2). If the HCO₃⁻ is out of range and reading low, the BE will also be out of range and reading low (in this case a negative number, less than –2).

**Other Parameters**
The more sophisticated blood gas analyzers are also able to measure lactate, glucose, crude urea and electrolyte levels, Hb and the anion gap. Lactate measurement is a particularly important marker in conditions such as sepsis (Dellinger et al, 2008).

While the focus of this article is on basic arterial blood gas analysis, once they are proficient in this, nurses may study further concepts.

**Portfolio Pages Online**
Portfolio Pages can be filed in your professional portfolio as evidence of your learning and professional development. They contain learning activities that correspond to the learning objectives in this unit, presented in a convenient format for you to print out or work through on screen.

For the Portfolio Pages corresponding to this unit, log on to nursingtimes.net, click NT Clinical and Archive then click Guided Learning

### Key References


NICE (2007) Acutely Ill Patients in Hospital: Recognition of and Response to Acute Illness in Adults in Hospital. London: NICE.


The full reference list for this unit is available in Portfolio Pages at nursingtimes.net