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ARTERIAL BLOOD GAS ANALYSIS 2: COMPENSATORY MECHANISMS

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This is the second of a two-part unit discussing arterial blood gas (ABG) analysis. Part 1 outlined background information on ABG reports and focused on a systematic approach to ABG analysis. This part examines the physiology of the various lines of defence in the body and explores the concept of compensation. A step-by-step guide to interpretation and examples of uncomplicated ABGs are available in the Portfolio Pages for this unit at nursingtimes.net, as well as further practice examples relevant to this part of the unit.

FIRST LINE OF DEFENCE

When the body suffers pH balance disturbances (whatever the cause), various mechanisms are set in motion to try to regain normality and ultimately preserve life. Metabolic control is the first line of defence and involves an extremely complex buffering system. Buffers are actually weak acids or weak bases, and can be imagined as being like sponges. They can bring about pH changes by either ‘soaking up’ excess hydrogen ions or ‘wringing themselves out’ to release hydrogen ions until the problem can be rectified. Buffers are only temporary holding measures and their actions cannot be sustained indefinitely. The buffers in the body include phosphate, the carbonic acid-bicarbonate system and plasma proteins such as albumin.

Carbonic acid-bicarbonate system

The equation \( \text{CO}_2 + \text{H}_2\text{O} \leftrightarrow \text{H}_2\text{CO}_3 \leftrightarrow \text{H}^+ + \text{HCO}_3^- \) is fundamental to understanding acid base balance. This is relatively simple to understand when split into five sections (see box, below). Central to the equation is carbonic acid, a weak acid that can split to the ‘left’ to form carbon dioxide and water, or to the ‘right’ to form hydrogen and bicarbonate.

When carbonic acid splits to form carbon dioxide and water, it can be excreted via the lungs and the kidneys respectively. When it splits to the right it forms hydrogen and bicarbonate. Bicarbonate can be excreted through the kidneys and can be lowered when used to ‘soak up’ excess acid in the blood. Hydrogen is only excreted through the urine in exchange for retention of other ions, mainly sodium. Nurses can check the extent of hydrogen excretion, as ‘normal blood’ with a pH of 7.4 produces urine with a pH of 5.0 (Woodrow, 2006).

SECOND LINE OF DEFENCE

When the buffers’ capabilities are exceeded, the second line of defence comes into action, which can be recognised within 2–3 minutes of a problem occurring. The chemoreceptors in the body sense the build-up of acids, and messages are sent via the respiratory centre to the lungs to increase the volume and rate of respiration. Acids can be converted to \( \text{CO}_2 \) by the carbonic acid-bicarbonate buffering system, and then exhaled from the body. Conversely, if the chemoreceptors sense a reduced amount of hydrogen ions in the blood, the

LEARNING OBJECTIVES

1. When interpreting an ABG result, be able to distinguish between the primary disorder and any evident compensatory action occurring.
2. Understand what the ABG shows and be able to relate this to the patient, their clinical presentation and immediate needs.
COMPENSATION
As far as possible, the body will compensate for pH imbalances until all reserve is lost and it can no longer do so.

The older patients are, the more co-morbidities they may be likely to have, thus making compensation more difficult. Similarly, the more serious their condition, the less likely it is that they will be able to compensate.

Compensation involves trying to create a state of ‘opposites’. For example, a patient suffering from respiratory acidosis will try to create the opposite state of metabolic alkalosis in order to compensate. Similarly, a patient in respiratory alkalosis will try to move to a state of metabolic acidosis. The principle of compensation is easy to remember as follows – the opposite of respiratory metabolic and the opposite of acidosis is alkalosis.

Determining the problem
When compensatory mechanisms occur it can be confusing at first to ascertain which abnormal parameter is the primary problem or underlying condition, and which constitutes compensation.

Nurses can make use of the ‘golden rules’ (discussed in the Portfolio Pages for this unit) and ascertain which parameter is moving in accordance with the pH. If the PaCO₂ is moving in the opposite direction from the pH, the patient will have a respiratory disorder. If the HCO₃ is moving in the same direction as the pH, the patient will have a metabolic disorder. This should then make the compensatory mechanisms more evident.

Compensation will involve the three main lines of defence discussed above, and it is only a temporary holding measure until the problem can be rectified. Metabolic conditions will be primarily compensated for by the respiratory system and respiratory conditions will rely on the renal system for compensation.

Chemical buffering
Chemical buffering also plays an important role and compensation can be partial or complete (although very rare), bringing the pH into the normal range.

This can be confusing for inexperienced practitioners, who might see the pH between 7.35 and 7.45 and think that the patient is well.