

# ***Arterial Blood Gases Monitoring & Interpretation for Anesthesia***

## ***Essay***

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By

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## *Aim of the work*

This essay aims to review the current medical literature with respect to arterial blood gas analysis, including blood gas and acid-base physiology, techniques for collection, handling and analysis of arterial blood samples and interpretation of the results during perioperative period.

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## **List of Abbreviations**

<b>ABG</b>	Arterial blood gas
<b>AIDS</b>	Acquired immunodeficiency syndrome
<b>ALI</b>	Acute lung injury
<b>ARDS</b>	Acute respiratory distress syndrome
<b>ASA</b>	American society of Anesthesiologists
<b>ATP</b>	Adenosine tri-phosphate
<b>ATPase</b>	Adenosine tri-phosphatase enzyme
<b>BB</b>	Buffer base
<b>BD</b>	Base Deficit
<b>BE</b>	Base excess
<b>BE<sub>ecf</sub></b>	Base excess extracellular fluid
<b>Ca<sup>++</sup></b>	Calcium ion
<b>CBF</b>	Cerebral blood flow
<b>CD</b>	Compact disc
<b>Cl<sup>-</sup></b>	Chloride ion
<b>CO<sub>2</sub></b>	Carbon dioxide
<b>CoA</b>	Acetyl coenzyme a
<b>COPD</b>	Chronic obstructive pulmonary disease
<b>CPAP</b>	Continuous positive airway pressure
<b>ctCO<sub>2</sub></b>	Total co <sub>2</sub> concentration
<b>ctO<sub>2</sub></b>	O <sub>2</sub> content
<b>DVD</b>	Digital versatile disc
<b>ECF</b>	Extra-cellular fluid
<b>ERV</b>	Expiratory residual volume
<b>FEV1</b>	Forced expiratory volume in 1st second
<b>FiO<sub>2</sub></b>	Fraction of inspired oxygen
<b>FRC</b>	Forced respiratory capacity
<b>FVC</b>	Forced vital capacity

<b>H<sup>+</sup></b>	Hydrogen ion
<b>[H<sup>+</sup>]</b>	Hydrogen ion concentration
<b>H<sub>2</sub>CO<sub>3</sub></b>	Carbonic acid
<b>H<sub>2</sub>O</b>	Water
<b>H<sub>2</sub>PO<sub>4</sub><sup>-</sup></b>	Dihydrogen phosphate ion
<b>Hb</b>	Hemoglobin
<b>HCl</b>	Hydrogen chloride
<b>HCO<sub>3</sub><sup>-</sup></b>	Bicarbonate ion
<b>HHb</b>	Deoxyhemoglobin
<b>HPO<sub>4</sub><sup>--</sup></b>	Hydrogen phosphate ion
<b>K<sup>+</sup></b>	Potassium ion
<b>LDH</b>	Lactate dehydrogenase
<b>MCT</b>	Monocarboxylate transporter
<b>Mg<sup>++</sup></b>	Magnesium ion
<b>mLDH</b>	Mitochondrial lactate dehydrogenase
<b>Na<sup>+</sup></b>	Sodium ion
<b>Na<sub>2</sub>HPO<sub>4</sub></b>	Disodium phosphate
<b>NaH<sub>2</sub>PO<sub>4</sub></b>	Sodium dihydrogen phosphate
<b>NaHCO<sub>3</sub></b>	Sodium bicarbonate
<b>NaOH</b>	Sodium hydroxide
<b>NH<sub>3</sub></b>	Ammonia
<b>NH<sub>4</sub><sup>+</sup></b>	Ammonium ion
<b>P(A-a)o<sub>2</sub></b>	Partial pressure (Alveolar to arterial gradient) of O <sub>2</sub>
<b>Paco<sub>2</sub></b>	Arterial carbon dioxide tension
<b>Pao<sub>2</sub></b>	Arterial oxygen tension
<b>Pco<sub>2</sub></b>	Carbon dioxide tension
<b>PDH</b>	Pyruvate dehydrogenase complex
<b>PE</b>	Pulmonary embolism

<b>PEEP</b>	The positive end expiratory pressure
<b>petco<sub>2</sub></b>	Partial pressure of end-tidal carbondioxide (amount of co <sub>2</sub> in exhaled air)
<b>pH</b>	Potential of hydrogen (negative log f H <sup>+</sup> )
<b>pHi</b>	Intramucosal pH
<b>PIOPED</b>	Prospective investigation of pulmonary embolism diagnosis
<b>pK</b>	the negative logarithm of the ionization constant (K) of an acid
<b>Po<sub>2</sub></b>	Oxygen tension
<b>QC</b>	Quality control
<b>RV</b>	Residual volume
<b>SaO<sub>2</sub></b>	Arterial o <sub>2</sub> saturation (measured directly by arterial sample)
<b>SB</b>	Standard bicarbonate
<b>SO<sub>2</sub></b>	Percent o <sub>2</sub> saturation
<b>SvO<sub>2</sub></b>	Mixed venous oxygen saturation
<b>TLC</b>	Total lung capacity
<b>TURP</b>	Trans-urethral resection of prostate
<b>V/Q</b>	Ventilation/perfusion ratio
<b>VC</b>	Vital capacity
<b>Vt</b>	Exhaled tidal volume
<b>Spo<sub>2</sub></b>	Blood o <sub>2</sub> saturation (measured indirectly by pulse oximeter)
<b>Δa</b>	change in alveolar ventilation

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# Introduction

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The introduction of electrochemical methods of analysis was in the mid-1900s; afterwards Donald D. van Slyke developed a more accurate manometric method, which became the gold standard of blood gas analysis for more than a quarter of a century. **(Severinghaus et al, 1998)**

Arterial blood gas (ABG) analysis is now common place in perioperative and acute-care settings and is used to aid diagnosis and to monitor the progress of the patient and the response to any interventions. It is essential that staff working in the perioperative environment understands the key principles of ABG analysis so that results can be dealt with quickly and appropriately **(Simpson, 2004)** as ABG is one of the most common tests performed in theatres **(Jevon et al, 2002)**.

Arterial blood gases will provide a set of values that can be used to determine key aspects of the patient's condition. These values can be broadly categorized into oxygenation status, adequacy of alveolar ventilation and acid-base balance **(Fitz-Henry et al, 2001)**. Normal cellular function is dependent on the  $pH$  being held within an extremely narrow range. Nevertheless, during acute illness in the perioperative period, if the body is unable to

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correct an abnormality of the  $pH$  this may eventually lead to such profound disturbance of acid-base balance that the patient could die (**Moore, 2000**).

Accurate results for ABGs depend on collecting, handling, and analyzing the specimen properly. Clinically important errors may occur at any of these steps. The most common problems include non-arterial samples, air bubbles in the sample, either inadequate or excessive anticoagulant in the sample, and delayed analysis of an uncooled sample (**Trulock, 2000**).

ABGs are now routinely measured with an automated analyzer. The basic components of such a unit are three electrodes, one each for determining  $IH$ ,  $PCO_2$ , and  $PO_2$  (**Trulock, 2000**). Continuous In-Vivo Techniques (*Miniature Electrode Systems*) can be used to continuously monitor in-vivo  $PO_2$ . (**Friedman et al, 2000**). The goal of future blood gas systems is to provide continuous, non-invasive, and accurate readouts of both the acid-base and oxygenation status of the patient (**Hess, 2000**).

**Transcutaneous** blood gas analysis would not be satisfactory in adults due to their thicker epidermis. (**Carter, 2011**) It shouldn't to be left in one place on the baby's skin for too long. (**Wright et al, 1993**) **Oximetry** readings may be inaccurate in the presence of hemodynamic instability, carboxy-hemoglobinemia,

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jaundice, or dark skin pigmentation. Also it can't detect hypercapnia or acidosis. **(Pierson, 1999)** In **sidestream capnometry** water vapor condenses in the sample tubing and the measuring chamber and produce erroneous readings. Response time is delayed. **(Miller et al, 2009)** In **mainstream capnometry** avoid skin contact with the warmed (40°C) measuring chamber. It is heavy to the circuit and may cause kinking of the endotracheal tube. It is prone to soiling with saliva or mucus because of their close proximity to the patient. **(Miller et al, 2009)**

# Physiology

## ***Physiology***

For regulation of hydrogen ion  $[H^+]$  balance there must be a balance between the intake or production of  $[H^+]$  and the net removal of  $[H^+]$  from the body. And the kidneys play a key role in regulating  $[H^+]$  removal. There are also multiple acid-base buffering mechanisms involving the blood, cells, and lungs that are essential in maintaining normal  $[H^+]$  concentrations in both the extracellular and the intracellular fluid (**Guyton et al, 2006**).

### ***pH***

$pH$  is the negative logarithm of the  $[H^+]$  ion concentration and the  $pH$  range compatible with life is (6.8–7.8), corresponds to a  $[H^+]$  concentration of 10–160 nmol/l. The concentration of free  $[H^+]$  in plasma is small approximately 40 nmol/l. (**Gennari et al., 2005**)  $pH$  is related to the actual  $[H^+]$  concentration by the following formula:

$$pH = \log \frac{1}{H^+} = -\log [H^+]$$

Therefore, the normal  $pH = -\log [0.00000004] = 7.4$

Small change in  $pH$  represents a relatively large change in  $[H^+]$  in the opposite direction (inversely related). A  $pH$  change of 0.3 units is equivalent to doubling or