Arterial Blood Gases Monitoring & Interpretation for Anesthesia

Essay

Submitted for partial fulfillment of

Master Degree in Anesthesia

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2014

Acknowledgement

First and foremost, I feel always indebted to **Allah,** the most beneficent and merciful.

I wish I could express my most sincere thanks, deep respect and appreciation to **Prof. Dr. Gamal Fouad Saleh Zaki,** Professor of Anesthesia and Intensive Care, Faculty of Medicine, Ain Shams University for his help and professional guidance in the supervision and careful review of the work.

I would like to thank and express my gratitude to **Dr. Heba Bahaa El-Dein El-Serwi,** Assistant Professor of Anesthesia and Intensive Care, Faculty of Medicine, Ain Shams University for her supervision and careful review of the work.

I would like to express my deeply thankful to **Dr. Rania Magdy Mohamed Ali,** Lecturer of Anaesthesia and Intensive Care, Faculty of Medicine, Ain Shams University for her guidance and great support during preparation of this work.

Finally, I would like also to thank **my family** for their support during this work.

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

ABG	Arterial blood gas
AIDS	Acquired immunodeficiency syndrome
ALI	Acute lung injury
ARDS	Acute respiratory distress syndrome
ASA	American society of Anesthesiologists
ATP	Adenosine tri-phosphate
ATPase	Adenosine tri-phosphatase enzyme
BB	Buffer base
BD	Base Deficit
BE	Base excess
BE_{ecf}	Base excess extracellular fluid
Ca^{++}	Calcium ion
CBF	Cerebral blood flow
CD	Compact disc
Cl^{-}	Chloride ion
CO_2	Carbon dioxide
CoA	Acetyl coenzyme a
COPD	Chronic obstructive pulmonary disease
CPAP	Continuous positive airway pressure
$ctCO_2$	Total co_2 concentration
ctO_2	O_2 content
DVD	Digital versatile disc
ECF	Extra-cellular fluid
ERV	Expiratory residual volume
FEV1	Forced expiratory volume in 1st second
$Fi0_2$	Fraction of inspired oxygen
FRC	Forced respiratory capacity
FVC	Forced vital capacity

H^+	Hydrogen ion
$[H^+]$	Hydrogen ion concentration
H_2CO_3	Carbonic acid
H_2O	Water
$H_2PO_4^-$	Dihydrogen phosphate ion
Hb	Hemoglobin
HCl	Hydrogen chloride
HCO_3^-	Bicarbonate ion
HHb	Deoxyhemoglobin
HPO_4^{--}	Hydrogen phosphate ion
K^+	Potassium ion
LDH	Lactate dehydrogenase
MCT	Monocarboxylate transporter
Mg^{++}	Magnesium ion
mLDH	Mitochondrial lactate dehydrogenase
Na^+	Sodium ion
Na_2HPO_4	Disodium phosphate
NaH_2PO_4	Sodium dihydrogen phosphate
$NaHCO_3$	Sodium bicarbonate
NaOH	Sodium hydroxide
NH_3	Ammonia
NH_4^+	Ammonium ion
P(A-a)o_2	Partial pressure (Alveolar to arterial gradiant) of O2
Paco_2	Arterial carbon dioxide tension
Pao_2	Arterial oxygen tension
Paco_2	Carbon dioxide tension
PDH	Pyruvate dehydrogenase complex
PE	Pulmonary embolism

PEEP	The positive end expiratory pressure
petco2	Partial pressure of end-tidal carbondioxide (amount of co_2 in exhaled air)
pH	Potential of hydrogen (negative log f H+)
pHi	Intramucosal *p*H
PIOPED	Prospective investigation of pulmonary embolism diagnosis
pK	the negative logarithm of the ionization constant (K) of an acid
Po_2	Oxygen tension
QC	Quality control
RV	Residual volume
SaO_2	Arterial o2 saturation (measured directly by arterial sample)
SB	Standard bicarbonate
SO_2	Percent o_2 saturation
SvO2	Mixed venous oxygen saturation
TLC	Total lung capacity
TURP	Trans-urethral resection of prostate
V/Q	Ventilation/perfusion ratio
VC	Vital capacity
Vt	Exhaled tidal volume
Spo2	Blood o_2 saturation (measured indirectly by pulse oximeter)
Δa	change in alveolar ventilation

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Introduction

Introduction

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 *p*H being held within an extremely narrow range. Nevertheless, during acute illness in the perioperative period, if the body is unable to

correct an abnormality of the *p*H 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,

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 capnometery** 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)**.

***p*H**

*p*H is the negative logarithm of the [H^+] ion concentration and the *p*H 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)** *p*H is related to the actual [H^+] concentration by the following formula:

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

Therefore, the normal *p*H = –log [0.00000004] = 7.4

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