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ARTERIAL BLOOD GAS AND PHYSIOTHERAPY SUPPLEMENTARY INDEPENDENT STUDY MATERIAL FOR PHYSIOTHERAPY STUDENTS

Degree Programme in Physiotherapy

2019

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Degree Programme in Physiotherapy
November 2019
Number of pages: 31

Keywords: acidosis, alkalosis, blood gases, metabolic, pH, physiotherapy, respiratory, renal

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This thesis is created to enhance physiotherapy students' knowledge in the topic of arterial blood gases by compiling information into a study package which can be used alongside the current curricula provided by Satakunta University of Applied Sciences. The aim of this thesis is to provide a comprehensive introduction into this topic; concerning arterial blood gases with physiotherapeutic viewpoint. This is done by providing reading material in a PDF file on the topic along with a short self-quiz questionnaire and practise material to test knowledge on subject independently to promote learning. The material in this thesis and study package was gathered by a literature review through combining information from various medical and academic sources.

Arterial blood gases are a reliable and swift way of assessing an individual's current state of health and are commonplace to test within both the emergency room and intensive care unit. In this study package, information on how, when, and why arterial blood gasses are tested, the physiology and chemistry behind influencing factors, as well as information on how to interpret results and use these in a physiotherapeutic practise will be explained in common language to promote self-learning. This aims to provide self-study material to prepare physiotherapist students who wish to work within these sectors with comprehensive knowledge on the topic of arterial blood gases.

CONTENTS

LIST OF ABBIVIATIONS

Acute respiratory distress syndrome ………………………… ARDS

Arterial blood gas .... ABG

Bicarbonate ……………………………………………... HCO3

Blood acidity ……………………………………………. PH

Carbon dioxide …………………………………………… PaCO2

Carbonic acid ……………………………………………... H2CO3

Chronic Obstructive Pulmonary Disease ……………………. COPD

Emergency room ……………………………………….. ER

Hydrogen …...…………………………………………... H+

Intensive care unit …………………………………………. ICU

Milli-equivalents per liter…………………………………... mEq/L

Partial pressure of oxygen PaO2

Potassium ………………………………………………… K

Oxygen ……………………………………………………. O2

Oxygen saturation SaO2

Sodium ………………………………………………….. NA

Venous blood gas ……………………………………….. VBG

Water……………………………………………………... H2O

1 INTRODUCTION

Interpreting arterial blood gas (ABG) tests can be an important if not mandatory skill for a physiotherapist depending on where one may work. For example, physiotherapists who work in intensive care, or with patients who are high risk in a respiratory ward, benefit from information that can be gathered from an ABG test. Knowing how to interpret ABG tests can assist with the planning of a patient's treatment, or maintenance and assessment of ventilators efficiency for those with respiratory failure. Within a hospital setting, understanding what can be done with a client before a scheduled ABG test is important as physical activity, for example exercise or movement that destabilizes patients breathing pattern, can alter the outcomes of an ABG test. (Pramod, Gunchan & Sandeep, 2010.)

By assessing blood pH levels and pulmonary gas exchange, ABG test results can indicate any disturbances in proper oxygenation and/or homeostasis. By this, useful information can be gained on possible respiratory or metabolic disorders when compared with a patient's previous and current medical information. (Yap & Tar Choon, 2011, 227.)

2 THE AIM AND OBJECTIVE OF THE THESIS

The aim of this thesis is to compile the information on what is measured during an ABG test and how to interpret the results. It will explain pH values in blood, show what are the factors which influence blood pH, and how the body regulates these influencing factors. In this study, the compilations and disorders that can result due to pH imbalance and poor oxygenation will be discussed from a physiotherapeutic viewpoint. The objective of this study is to provide the information in a comprehensible, common language for the benefit of the student reader. This thesis aims to demonstrate the reasons for ABG testing and why a physiotherapist should understand and take into account the results.

3 ARTERIAL BLOOD GASES

Arteries transport oxygenated blood from the heart to the rest of the body. The blood transports oxygen (O2), carbon dioxide (CO2), electrolytes such as potassium (K), and ions. These elements are needed to help the body run smoothly and maintain homeostasis. Imbalances of these elements can cause the body to malfunction. They can be an indicator of a disorder. By measuring the amounts of these elements in the blood stream, it can help indicate certain conditions in the body. Measurement of these elements are done by an arterial blood gas (ABG) test. (Colduvell 2017; Sood, Paul, & Puri 2010.)

ABG tests are useful in diagnosis of a patient condition and construction of a treatment plan. For an individual on a ventilator, an ABG can assist with its management of its settings. It can assist with medication prescriptions and is also a good indicator of acid – base disorders. By measuring the levels of O2 and CO2 in the blood, it can show the body's ability to absorb O2 and remove CO2. Dysfunction in this processcan indicate problems within the respiratory, metabolic, and renal system as well as other conditions such as diabetics, trauma, or drug overdose. (Colduvell 2017; Sood, Paul, & Puri 2010.)

To test ABGs, a blood sample around 0.5 ml to 1 ml of blood is taken from either the radial artery, brachial artery, or femoral artery. This is generally done by a nurse and is then sent to a lab in the hospital for analysis. Results are ready in about 15 minutes. This makes an ABG test relatively swift and a low risk method to gain information on patient's current state. (Colduvell 2017)

Table 1. Compounds included in an ABG test (Colduvell 2017)

Compound	Abbreviation
Blood acidity	pH
Oxygen saturation	O2
Partial Pressure of Oxygen	PaO2
Partial pressure of Carbon dioxide	PaCO2
Bicarbonate	HCO3

The different levels of these elements within the arteries can point to various disfunctions depending on the values found. Some other elements that can be measured during an ABG test are hemoglobin (Hb), lactic acid, and electrolytes e.g. potassium (K), sodium (Na).

What these individual compounds seen in table 1 indicate, are as follows. PH indicates the bloods acidity. Whether there is alkalosis (alkaline condition) or acidosis (acidic condition). SaO2 indicates the hemoglobin combined with O2 percentage. This can show presence of hypoxemia, when the oxygen saturation in the body is at an abnormal low. PaCO2 indicates the amount of CO2 in the blood. PaO2 indicates the amount of O2 in the blood. HCO3 indicates the amount of bicarbonate in the blood. (Tidy 2015.)

Depending on the values of these components in the blood, they can suggest towards malfunction or compensation within the body. For those who are in critical condition even a slight change in these values can cause a severe turn for the worse. The use of ABG tests provides a reliable and fast way of assessing a patient's immediate condition. (Colduvell 2017.)

While blood pH and CO2 can also be assessed through a venous blood gas (VBG) test, this method proves unreliable when reading O2 levels. This is why ABG tests have become a standard test for those with a severe respiratory condition or in critical condition. It is commonplace to regularly test patient's ABG within an intensive care unit (ICU) settings as well as in emergency room (ER), although they can be tested in other departments as needed. (Colduvell 2017.)

4 ACID-BASE BALANCE

One of the main functions of an ABG test is to determine an individual's blood pH. This can be of great use when diagnosing or treating, especially those in critical condition. Assessing if the individual's pH value is within or out of the norm of 7.35 - 7.45pH can indicate improper function of the body's acid – base regulators. A value lower than 7.35pH indicates the body is in acidosis, meaning acidic levels in the blood are too high. A value above 7.45pH indicates the body is in alkalosis, meaning the pH level in the blood is too base. This balance is imperative for protein stability and the biochemical processes. Without it, enzymes unfold and no longer function at their correct level. A pH level below 7.00pH or above 7.80pH becomes unsustainable for life and death can occur. (Donaldson & Lamont 2013.)

So, what is pH? PH is the measurement of acidity or alkalinity of a solution. This is done by measuring the concentration of H+ within the solution. Most solutions will fall somewhere in the category from 14pH to 0pH, with 7pH being neutral. Each value of 1 in pH is equal to x10 H+. Pure distilled water is at 7pH and has a H+ concentration of .0000001. Sea water has a value of 8pH and has a H+ concentration .00000001. A simple way to remember this is that the number value of pH is equivalent to the location of the decimal point: 1 pH = 0.1 H+, 2 pH = 0.01 H+, 3 pH = 0.001 H+, etc… (Website of Academics Brooklyn College 2019.)

To put this all into perspective, bleach which is alkaline sits at 13 pH and sulfuric acid sits at a 0 pH. Pure distilled water is just around the middle of these values at a 7 pH and is neutral. So simply put, anything above a 7 is alkalotic and below is acidic. Blood sits at around 7.40. Meaning blood sits normally slightly alkalotic. For life, the gap of which a human can tolerate pH variables is thin. With only a 0.10 variable gap between the normal values of 7.35 and 7.45, it is imperative that the human body maintains this equilibrium. There are 3 systems in which the body regulates its pH. These are the chemical buffer, respiratory system, and renal system.
(Website of Khan Academy 2019.)

4.1 Blood pH influencers

Before understanding the systems responsible for regulating blood pH, an understanding of what is responsible for blood to be either acidic or alkaline must be gained. The production of CO_2, which is an acidic compound, is a by-product of cellular metabolism. This is expelled into the blood stream continuously; increasing the acidic levels of blood. CO_2 combines with H_2O to create H_2CO_3, this in turn splits into H^+ and HCO_3. This equation is responsible for acid-base balance. An increase on one side will cause an increase on the other side. (Ibsen 2019.)
The following is the chemical equation for homeostasis in the human body:

$$CO_2 + H_2O = H_2CO_3 = H^+ + HCO_3$$

When the concentration of CO_2 increases the equilibrium causes an increase of H^+. As pH is a measurement of the concentration of H^+ within a solution, the greater the amount out H^+ the grater the acidity and lower the pH. To achieve balance, the body then must expel CO_2 and H^+ and retain HCO_3. The elimination of CO_2 and H^+ reduces acidity, while the retention of HCO_3 increases alkalinity. The reverse would be the same, if the body had an alkaloid imbalance. (Ibsen 2019.)

4.2 The chemical buffer

The chemical buffer, a continuous chemical reaction located in the blood, is the first to react, when there is an excess or lack of H^+. It consists of proteins, phosphate, and ions such as carbonic acid (H_2CO_3) and bicarbonate (HCO_3). These elements take only seconds to react to a pH imbalance in the body. They neutralise the pH by adding or absorbing H^+. Take for example: the relation between H_2CO_3 and HCO_3. When the concentration of H^+ is too high HCO_3 will absorb the excess becoming H_2CO_3. In reverse when the concentration of H^+ is low then H_2CO_3 will turn to HCO_3 and produce H^+ to restore the balance. This system maintains the pH balance in the body from fluctuation. (Website of Sydney University, Discipline of Anaesthesia 2015.)

The chemical buffer only takes a few seconds for this process, but has a finite amount that it can buffer against, before the imbalance becomes too great. When the imbalance gets to this size, it is then up to the respiratory or renal system to provide stability. (Website of Sydney University, Discipline of Anaesthesia 2015.)

4.3 Respiratory control

The lungs' primary influencer on the body's pH is controlling the levels of PaCO2. This is done by the retention or expulsion of CO2. The range in which PaCO2 is considered normal is 35 – 45 mmHg. If the level of PaCO2 rises this will trigger the exhalation of CO2 and if it was to fall it would trigger the retention of CO2. Because CO2 is acidic the amount exhaled has a direct influence on blood acidity. (Website of Sydney University, Discipline of Anaesthesia 2015.)

An example of CO2's influence on blood acidity can been seen on both extremes in the form of hyperventilation or hypoventilation, increasing or decreasing the amount of CO2 leaving the body respectively. This will cause a change of blood pH due to an excess or loss of an acidic influence in the blood. This will result in what is called respiratory alkalosis, caused by lack of CO2 and respiratory acidosis, caused by the excess of CO2. Both respiratory alkalosis and respiratory acidosis can be caused by a multiple of other respiratory malfunctions and if left untreated can be harmful to the body. (Website of Sydney University, Discipline of Anaesthesia 2015.)

4.4 Renal control

The kidneys' role in pH balance is to regulate the reabsorption of HCO3 and eliminate fixed acids. This is done through the proximal and distal tubular mechanism. These are part of the renal tubule within the kidneys that attach to the glomerulus and filter blood. The proximal tubule is responsible for the reabsorption of HCO3. On average, in a healthy body, 4,000 to 5,000 mmol of HCO3 is filtered and 80% to 90% is reabsorbed back into the bloodstream a day. The distal tubular however, is responsible for the excretion of acid and H+ which is then eliminated from the body through urine. Urine's pH has an acidic limitation no greater than 4.40 pH. The average amount of acid removed and eliminated is around 1 mmol per body kilo a day. (Brandis 2016 4.2.)

When the renal system malfunctions acidosis or alkalosis can occur. Metabolic acidosis can occur when there is renal failure and the kidneys are unable to eliminate excess acids. Whereas hypercalcemia, an excess of calcium in the blood, can cause excess HCO3 to be reabsorbed by the proximal tubule and cause metabolic alkalosis. Metabolic acidosis and alkalosis are also cause by malfunctions outside of the renal system. (Thomas 2018; Brandis 2016 4.2.)

4.5 PH balance though systemic compensation

The body functions within a balance of all its systems and elements. When something becomes unbalanced, the body will look for ways to restore order. When the respiratory system changes its normal processing as a result of a metabolic change, or the renal system does the same for respiratory, this is called compensation. While compensation will not completely level out an imbalance and will never exceed past minimal requirement for normal pH, it is an important part in the body's acid - base control. (Website of Sydney University, Discipline of Anaesthesia 2015.)

When there is an imbalance in the body's pH, whether metabolic or respiratory, the opposing system will strive to find a way to correct the balance. The respiratory control will attempt to compensate for a metabolic imbalance and can start the process within minutes to hours. The renal system on the other hand, may take days to start the proses of compensating for a respiratory malfunction. (Website of Sydney University, Discipline of Anaesthesia 2015.)

5 INTERPRETING ABG TEST

Interpreting an ABG test can be at first confusing, but with some techniques it can become easy. First, it is important to remember your normal values. Are the test results within the norm? If not, which of the values are abnormal and what do these abnormalities mean? (Colduvell 2017.)

5.1 Normal values

The elements tested in an ABG test have norms that can vary slightly within a "healthy amount". If any of the values are higher or lower than the norm, this indicates a malfunction. See table 2 for normal values of these elements. (Colduvell 2017.)

Table 2 Normal values in ABGs. (Colduvell 2017.)

Compound	**Abbreviation**	**Normal Values**
Blood acidity	pH	7.35-7.45
Oxygen saturation	O2	94%-100%
Partial Pressure of Oxygen	PaO2	75-100 mmHg
Partial pressure of Carbon dioxide	PaCO2	35-45 mmHg
Bicarbonate	HCO3	22-26 mEq/L

The range in which an individual can tolerate being out the normal values varies from compound to compound in an ABG test. One simple rule of thumb to remember is, the larger the gap the longer the patient can tolerate being out of the normal value. For example: PaCO2 has 10 units gap that define normal values, pH has 0.10-unit gap that define normal values. Patients can tolerate being out of normal PaCO2 values for longer compared to pH. This is because the normal unit gap is wider in PaCO2 than in pH. The longer one can tolerate, will mean less symptoms they will display. (Colduvell 2017.)

5.2 Interpreting abnormalities

When reading the values of a an ABG test, it can help to think, of if the value as whether it is acidosis or alkalosis instead of if it is high or is it low. When assessing acidosis and alkalosis the values looked at are pH, PaCO2, and HCO3. SaO2 and PaO2 are used to assess proper oxygenation. When pH and HCO3 are above the normal value, they are alkalotic while lower than normal value is acidotic. PaCO2 on the other hand, is the opposite with high meaning acidotic and low alkalotic. Low values of SaO2 and PaO2 indicate hypoxemia. It is impossible to have a value higher than 100% SaO2, which is within the recommend range. If the value of PaO2 is higher them 100mmHg this indicates that the patient is on oxygen therapy, as this is a value which cannot be reached through natural respiration. Table 3 demonstrates these values and their indication. (Bartlett 2019.)

Table 3. ABG elements in abnormal values (Bartlett 2019.)

Value	∨ **Value (low)**	∧ **Value (high)**
pH	Acidosis	Alkalosis
CO2	Alkalosis	Acidosis
PaO2	Hypoxemia	O2 therapy
HCO3	Acidosis	Alkalosis
SaO2	Hypoxemia	

5.3 Respiratory or Metabolic

When looking at acid-base disorders, the three measures needed are pH, PaCO2, and HCO3. While pH is the main indicator of acid – base disorders, PaCO2 and HCO3 indicate where the disorder stems from. PaCO2 represents the respiratory system and HCO3 represents the metabolic. When pH and PaCO2 are of opposing values, such as a high pH and low PaCO2, the disorder is of respiratory nature. When pH and HCO3 are the same value then the disorder is metabolic. The easiest way to remember this is ROME: respiratory = opposite, metabolic = equal. An example of this would be, if both pH and HCO3 are alkalotic and PaCO2 in normal then the disorder would be metabolic alkalosis. (O'Donnell. 2008.)

Tables 4-7 show examples.

Table 4 respiratory acidosis (O'Donnell. 2008.)

Mesure		Value	Acid-Base
pH		7.22	ᵛ Acidosis
PaCO2		50 mmHg	^ Acidosis
HCO3		24 mEq/L	norm

Table 5 respiratory alkalosis (O'Donnell. 2008.)

Mesure		Value	Acid-Base
pH		7.5	^Alkalosis
PaCO2		28 mmHg	ᵛ Acidosis
HCO3		24 mEq/L	norm

Table 6 metabolic acidosis (O'Donnell. 2008.)

Mesure		Value	Acid-Base
pH		7.22	ᵛ Acidosis
PaCO2		38 mmHg	norm
HCO3		18 mEq/L	ᵛ Acidosis

Table 7 metabolic alkalosis (O'Donnell. 2008.)

Mesure		Value	Acid-Base
pH		7.5	^ Alkalosis
PaCO2		38 mmHg	norm
HCO3		32 mEq/L	^ Alkalosis

5.4 Discerning compensation in ABG test results

The body will try and compensate for an any imbalance in order to maintain homeostasis. When blood pH fluctuates outside the norm due to either a respiratory or metabolic disfunction then the other system will attempt to return the pH back to normal. When this happens, it is either respiratory compensation or metabolic compensation depending on which is compensating for the other. (O'Donnell. 2008.)

There are two categories in compensation, partial and complete. Partial compensation is when the non-affected system attempts to balance the pH, but will not fully regain normal balance. Complete compensation is when the non-affected system succeeds in correcting the pH balance. The body can never overcompensate. The compensation of the nonaffected system will never switch the disorder e.g. turning acidosis to alkalosis and vice versa. (O'Donnell 2008.)

5.4.1 Partial compensation

If all the measurement values are abnormal, then there is partial compensation. To tell which system is compensation for the other, first obtain what is the condition. Is the pH abnormal? If so, is it respiratory or metabolic? Then look at the remaining measurement, is it abnormal? Two ways of obtaining the acid-base disorder and possible compensation are to look at whether the values are high or low or if the measures are acid or base. (O’Donnell. 2008.)

To interpret values, look to see if all the values are in the same direction or not. If PaO2 and HCO3 match and pH opposes, then it is a respiratory condition with metabolic compensation. If all the values go in the same direction, then it is a metabolic condition with respiratory compensation. (O’Donnell. 2008.)

Example: high pH, Low PaCO2, low HCO3 = respiratory alkalosis with metabolic compensation.
Example: high pH, high PaCO2, high HCO3 = metabolic alkalosis with respiratory compensation.
Remember **ROME**.

Another way to asses this, is to read the values as acidic and alkalotic. Whichever measure matches the pH, then this is the condition. The opposing value will equal the compensation system. (O’Donnell 2008.)

Example: high pH (alkalotic), low PaCO2 (alkalotic), low HCO3 (acidotic) = respiratory alkalosis with metabolic compensation.
Example: high pH (alkalotic), high PaCO2 (acidotic), high HCO3 (alkalotic) = metabolic alkalosis with respiratory compensation.
See table 8-11 for examples of partial compensation.

Table 8 Respiratory acidosis with metabolic compensation. (O’Donnell. 2008.)

Mesure		Value	Acid-Base
pH		7.22	˅ Acidosis
PaCO2		50 mmHg	^ Acidosis
HCO3		32 mEq/L	^ Alkalosis

Table 9 Respiratory alkalosis with metabolic compensation. (O’Donnell. 2008.)

Mesure		Value	Acid-Base
pH		7.5	^Alkalosis
PaCO2		28 mmHg	˅ Acidosis
HCO3		18 mEq/L	˅ Acidosis

Table 10 Metabolic acidosis with respiratory compensation. (O'Donnell. 2008.)

Mesure		Value	Acid-Base
pH		7.5	^ Alkalosis
PaCO2		50 mmHg	^ Acidosis
HCO3		32 mEq/L	^ Alkalosis

Table 11 Metabolic alkalosis with respiratory compensation. (O'Donnell. 2008.)

Mesure		Value	Acid-Base
pH		7.22	˅ Acidosis
PaCO2		28 mmHg	˅ Acidosis
HCO3		18 mEq/L	˅ Acidosis

5.4.2 Complete compensation

When the compensating system equalizes blood pH, this results in complete compensation. This can be seen, when the pH is within normal values, while PaCO2 and HCO3 are abnormal. Since compensation will never achieve a perfect pH equilibrium of 7.40, perfect middle of 7.35 and 7.45, the compensation mechanism can still be determined through alkalotic norm 7.41 to 7.45 and acidotic norm 7.35 to 7.39. By using either method of determining compensation (values variations or acid-base measures), look to see if the pH is an "alkalotic normal value" or "acidotic normal value" i.e.: above or below 7.40. (O'Donnell 2008; Lampert 2016.)

Example: alkalotic norm pH (7.41-7.45), low PaCO2 (alkalotic), low HCO3 (acidotic) = respiratory alkalosis with complete metabolic compensation.
Example: acidotic norm pH (7.35-7.39), low PaCO2 (alkalotic), low HCO3 (acidotic) = metabolic alkalosis with complete respiratory compensation.
(O'Donnell. 2008.)

6 INDICATIONS, CONDITIONS AND SYMPTOMS

ABG test are most common in hospital setting, more specifically in ICU and ER. Medical and therapeutic practitioners working in these wards will come across ABG tests on a regular basis. Knowing when a test should be administered and what are some of the conditions and symptoms that a patient may demonstrate, when their ABGs irregular, is important within these sectors. (Danckers & Fried 2018.)

6.1 Indications

There are a wide range of disorders and conditions that are indictors for ABG testing. The main reasons one would request an ABG test to be done for a patient, would be to aid with diagnosis and treatment planning, for patients in critical condition and those with respiratory failure in need of total or partial respiratory assistance, and regulation of ventilators, medications and acid base disorders. Other indicators for ABG testing are organ failure of the heart, liver, kidney, and lungs, diabetes in hyperglycemic and ketoacidosis states, trauma or shock, poisoning or drug overdose, COPD, hemorrhage, asthma, sepsis, excessive and prolonged vomiting, and smoke or water inhalation.
(Fraser & Haldeman-Englert 2019; Colduvell 2017; Tidy 2015.)

6.2 Symptoms and conditions of acid-base imbalances

ABG tests are one of the methods used to assess for acid base disorders. To make a full diagnosis of a patient's condition other testing is done alongside ABG tests. The first thing to recognize is symptoms, test to confirm acid base disorder, and then test further to diagnose. This is done through various methods depending on the condition. Some of the tests done alongside or after ABGs are: X-rays, further blood or urine tests, and physical tests. Understanding symptoms of acidosis and alkalosis, as well as possible conditions that they could stem from, is important when treating an individual with indications of a possible ABG imbalance. (Fraser & Haldeman-Englert 2019.)
For complete list of symptoms see table 12.

Table 12 Symptoms of acidosis and alkalosis. (Young et. Al.. … 2013. 185)

System	Acidosis	Alkalosis
Central nervouse	headache	confusion
	sleepiness	light-headed
	confusion	stupor
	loss of consciousness	coma
	coma	
Peripheral nervous		hand tremor
		numbness or tingling
Respiratory	shortness of breath	
	coughing	
Muscular	seizures	twitching
	weakness	prolonged spasms
Digestive	nausea	nausea
	vomiting	vomiting
	diarrhea	
Cardeovascular	arrhythmia	
	increased heart rate	

6.2.1 Acidosis

While symptoms of both respiratory and metabolic acidosis are similar, there is one main difference. While those experiencing either respiratory or metabolic acidosis may feel fatigue and confusion, a respiratory acidotic individual will experience shortness of breath, while an individual with metabolic acidosis will experience rapid breathing. While some of the symptoms are similar, the cause of these symptoms very widely. (Pietrangelo 2016)

Some factors that may cause respiratory acidosis are injury or deformity of the chest, respiratory difficulties caused by disease or sedatives, and obesity. The influences on metabolic acidosis range from uncontrol diabetes resulting in ketoacidosis, loss of NA and/or HCO3 due to excessive and prolonged diarrhea, resulting in hyperchloremic acidosis, to an excess of lactic acid. Many conditions may cause an excess of lactic acid in the body. Some of these are kidney or liver disease/failure, excessive exercise, medication, cancer, dehydration, oxygen deprivation, low blood glucose, and certain poisoning caused by excess alcohol, aspirin and methanol. (Pietrangelo 2016)

6.2.2 Alkalosis

The symptoms of alkalosis are vaster than acidosis and do not vary whether of a respiratory or metabolic origin. These symptoms include vomiting or nausea, twitching or spasms, numbness or tingling, tremor in the hands. and confusion or light-headedness. An individual with alkalosis may experience one or multiple of these symptoms. (Pietrangelo 2016)

There are few metabolic causes of alkalosis. These are particular prescribed diuretics or excessive vomiting. This triggers metabolic alkalosis due to loss of potassium and chloride. Respiratory alkalosis can derive from many conditions that can cause decreased levels of CO2 in the blood. These include lung or liver disease, fever, oxygen deprivation or thin air caused by altitude, and poisoning by excess salicylate; found in many drugs such as aspirin. (Pietrangelo 2016; Website of drugs.com 2019)

6.3 Symptoms and conditions of hypoxemia

Hypoxemia occurs when there is a low amount of O2 in the blood stream. When arterial blood has a low content of O2 this is called hypoxic hypoxia. This results in low PaO2 and SaO2. Affecting the entire body hypoxic hypoxia is the dangerous type of hypoxia. This is a severe condition that can cause organ damage swiftly if not treated immediately. Symptoms of hypoxemia are cyanosis (blue hue of the skin caused by low O2), shallow or shortness of breath, coughing, increased heartbeat, confusion and/or disorientation, and headache. (Seladi-Schulman. 2019; Cafaro. 1960.)

Along with ABGs, pulse oximetry, and breathing tests may be done in order to diagnose the cause of hypoxemia. Conditions that can cause hypoxemia are complications in the lungs such as clots, collapsing, and scaring, fluids, lung disorders such as asthma, COPD, ARDS, and pneumonia, sleep apnea, high altitudes, anaemia, medications, heart disease or defects. O2 therapy is the most common treatment of hypoxemia. It aims to raise O2 levels in the body by increasing O2 intake through a mask, nasal tube, or ventilator. (Seladi-Schulman. 2019; Cafaro. 1960.)

7 APPLYING KNOWLEDGE IN PHYSIOTHERAPEUTIC TREATMENT PLAN

In both ER and ICU wards a physiotherapist will come in contact with ABG tests on a regular basic. A knowledge of what these tests monitor and what may influence results is important when working in these sectors. (Higgins 2016; CPS. 2011; Bartlett 2019)

ABG tests are generally administered by nursing staff. General guidelines are, to test for ABGs on a patient who has be stable for minimum of 15minutes. As a physiotherapist, this could mean, when seeing a patient, to discuss with the other medical professionals caring for patient, and if an ABG test is due to be administered, wait until after this is completed, to treat the patient. Activity that increases breathing rate and heart rate can cause the reading of the test to show results that are not true to the individual's norm. Note that those in critical condition or those who have not had much activity may experience what most think of as easy and simple activities to be strenuous. Those who have been on bed rest, may find that the seemingly simple act of sitting on the edge of a bed, may result in increased heart rate and shortness of breath. This can affect the accuracy of the test. (Higgins 2016; CPS. 2011; Bartlett 2019)

Chest or respiratory physiotherapy is aimed at increasing respiration quality by strengthening the respiratory muscles, gaining proper breathing techniques, and clearing obstructions. There are many techniques a physiotherapist may use to achieve this. These include percussion, vibration, suction, positioning, instruction of proper breathing techniques, positive expiratory pressure exercises, assisted cough, and many more. These methods improve PaO_2 and SaO_2 levels as well as regulate $PaCO_2$ and have other beneficial effects on gas exchange. Movement and exercise show benefits on this too, when a patient is at a health level that this is appropriate. Proper physiotherapy is to know when it is appropriate to do a treatment, as much as it is to know when the said treatment is not appropriate. Being able to adapt a therapeutic plan to the patient's current condition is part of a physiotherapeutic planning. (Walker, Hall & Hurst 1990; Santos MSc. AL 2014; Shaphe, Geelani, Moiz& Aggrawal 2011; Gunay AL 2016)

Patients whose health are in critical condition can fluctuate from session to session. Reading the most resent ABG test results can show a patient's current health. When put together with past tests, one can also see the stability of the patient. These results can indicate what treatment is appropriate at the moment. For example, if a patient has extreme variations on an ABG test, it may be best not to exert them until they have become medically stable. Vigorous exercise may provoke acidosis. This can trigger muscle fatigue. If in doubt about what is appropriate for a patient, once abnormal results are noted, ask their medical caretaker. Discuss and work with the multi-professional team to gain the best treatment for the client. It is important to be able to understand these results and discuss with the doctors and nurses to know what is suitable for the patient before treating. (Lindinger 2016; CPS 2011)

8 THESIS PROCESS AND METHODS

This thesis is an archival study with the purpose of making a practical study material on the topic of arterial blood gases. The information compiled is from medical books, scientific articles, government and scholastic websites, as well as other reliable literature sources. Multiple sources and sectors in the medical field were used in the creation of the supplementary study material for physiotherapy students. The aim of this was for future SAMK students to gain knowledge on the topic and to be able to apply the knowledge in physiotherapeutic practice. Sixteen articles, 3 books, 3 higher education websites among other souses, were used in this study. From this study a 23-page written study material was composed depicting the physiology and chemistry involved in the body, the elements tested and how the test is administered, indications and symptoms, as well as gridlines for treating abnormalities from a physiotherapeutic viewpoint all pertaining to the topic of ABGs.

9 DISCUSSION

In composing supplementary independent study material for the physiotherapy students of SAMK, archiving the information available on the physiological and medical aspects of ABGs had to limit the topics covered due to the vast amount of information on the topic. Topics such as electrolytes and hemoglobin, both which can also be tested during an ABG test, had to be forgone due to length limitations in this study material. How the amounts of these elements affect one's health or delving deeper into the chemistry of pH values in the body, could be a further study in itself. How the limits of this study material was decided, was to give the reader an overall view of ABGs from the chemistry and physiology, to testing and treating, in under 30 pages. With the information compiled the reader should gain an understanding from a physiotherapist point of view on the topic and precautions to take when treating a patient with abnormal ABG results.

To better understand a how a physiotherapist can improve the health of the patient with abnormal ABG results, further research needs to be done. A second archival study could be done with the research available at the moment, but there is a need for more readily available and reliable studies on physiotherapeutic methods and their particular affect on the various measurements within the ABG test. On this side of the topic the information available becomes condition specific, and many do not take in account all aspects of ABG. There is also a lack of studies pertaining to many specific conditions. This leaves a gap in knowledge on particular physiotherapeutic methods and their effect on different conditions. Due to this, the physiotherapeutic guidelines, for treating abnormal ABG results compiled for this material, were written in general guidelines affecting all conditions showing abnormalities. For method and condition specific therapy, further research and studies need to be done.

10 LIMITATIONS

Upon researching this topic, the author found the availability of information on ABGs to vary greatly between medical and therapeutic sectors. The majority of the articles and books written on ABGs are written by or for nursing and medical staff. While these contained an abundance of quality information on the subject, the author found information to be lacking, when written from a physiotherapeutic point of view. While in many countries this is a subject taught and expected of physiotherapist to know, there is a severe lack of readily available literature on this subject in the physiotherapy sector.

The majority of the information gathered for this study material has been taken from nursing and medical websites, articles, and books. These did provide a plethora of information on ABGs, their influencing systems, interpretation of tests results, as well as indications, symptoms, and disorders in relation to ABGs. They provided little information on physiotherapeutic influence on ABGs. The author did manage to find few studies on specific disorders, and respiratory physiotherapists' influence on APGs. These did show good evidence of respiratory physiotherapy on improvement of gas exchange. By combining the information on these specific studies as well as guidelines from medical and nursing literature, the author managed to combine more comprehensive understanding of ABGs and physiotherapeutic correspondence to their testing and results. This said, more information on this subject and all conditions pertaining to ABGs would be needed to fully comprehend and delineate the physiotherapeutic treatment and influence on ABGs.

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