

Respiratory system and maintaining blood ph

[Science](#), [Anatomy](#)



**ASSIGN
BUSTER**

School of Nursing, Midwifery and Interprofessional Studies. With reference to acid-base balance explore the role of the respiratory system in maintaining blood pH? 'We live and die at the cellular level' (Reid, 2011). Homeostasis is crucial for normal cellular function. Acid-base homeostasis is the part of human homeostasis and refers to the balance between the production and elimination of H^+ hydrogen ions (pH) within the body fluids (William, Simpkins, 2001, p. 236). Metabolic reactions within the cells often produce a huge excess of H^+ .

Lack of any mechanism for its excretion would lead H^+ levels in body fluids rise quickly to the lethal levels (Tortora, Grabowski 2006, p. 1001); therefore the homeostasis of the right H^+ levels is crucial for our survival. In a healthy person several systems work interdependently on maintaining blood's pH (Sheldon, 2001, p. 23): buffer, renal and respiratory systems. In this essay I will concentrate on the pH of the blood in relation to the acid-base balance and the role that respiratory system has in maintaining it. Blood pH is a measure of its acidity or alkalinity. A pH of 7. is considered neutral in the systemic arterial blood within its narrow range of around 7. 35 and 7. 45. When the pH is greater than 7. 45 the blood is considered to be alkalotic and when the pH is lower than 7. 35 then the blood is considered acidotic (Sheldon, 2001, p. 23). Fig. 1: Diagram of blood pH scale: (Jupiterlonizer, 2004) The acidity or alkalinity of blood is a result of H^+ concentration within it, and this on the other hand results from the carbon dioxide concentration in the blood. Carbon dioxide is a toxic waste product generated in the oxidation of fats, carbohydrates and proteins within the cells.

The gas itself is not an acid, but it reacts with water to form carbonic acid which then dissociates to form a hydrogen ion and a bicarbonate ion: $\text{CO}_2 + \text{H}_2\text{O} \rightleftharpoons \text{H}_2\text{CO}_3 \rightleftharpoons \text{H}^+ + \text{HCO}_3^-$. The respiratory system helps to control the acidity of blood by regulating the elimination of CO_2 and H_2O through ventilation and on the other hand, blood pH (H^+ concentration) plays a major role in respiratory control. Respiratory muscles belong to the voluntary breathing system and are controlled by the respiratory centre located in the medulla oblongata and the pons of the brain stem (Hinchliff, Montague, Watson, 2005, p. 605). Gregoire and Gallagher (2004, p. 24) suggest, that the breathing centre controls a number of inseparable parts, which work together to ensure that any inspiration is harmoniously followed by an appropriate expiration. Also, the frequency and the volume of air per inspiration are regulated. In order to regulate the breathing in an efficient manner, the respiratory centre must be informed of the need for the ventilation in the body mainly by chemoreceptors which are sensitive to the PCO_2 (carbon dioxide pressure) or the pH of the blood. Those chemoreceptors can be found in the aortic arch and in the carotid artery (Thomson, Adams, Cowan, 1997, p. 1). According to Tortora and Derrickson (1006, p. 1002), the pH of bodily fluids and breathing rate react via the negative feedback loop. When the aforementioned chemoreceptors detect any changes in blood pH, they will stimulate the respiratory centre to alter the ventilation rate in order to bring the acid-base balance to its homeostatic level. When the blood acidity increases, the pH decreases and causes the chemoreceptors to stimulate the inspiratory area in the brain. This results in

diaphragm and other respiratory muscles to contract more frequently and forcefully (resulting in increased CO₂ excretion).

This will cause less H₂CO₃ to form, therefore less H⁺ will be present in the blood, resulting in increase of blood's pH. When this response will bring blood pH back to normal, its acid-base balance will be back to its homeostatic level (Tortora, Derrickson, 2006, p. 1002). The same negative feedback will respond, when the blood CO₂ level will increase (increase in ventilation, therefore CO₂ excretion from the blood, reducing its H⁺ concentration and finally increase in pH). Hypoventilation= CO₂ = H⁺ = pH = Acidosis Hypoventilation= CO₂ = H⁺ = pH = Acidosis CO₂ CO₂

H⁺ H⁺ pH pH Normal blood pH (7. 35-7. 45) Normal blood pH (7. 35-7. 45) Chemoreceptors stimulate the respiratory centre Chemoreceptors stimulate the respiratory centre Breathing becomes slower and shallower Breathing becomes slower and shallower Chemoreceptors stimulate the respiratory centre Chemoreceptors stimulate the respiratory centre Breathing becomes deeper and faster Breathing becomes deeper and faster pH pH H⁺ H⁺ CO₂ CO₂ Hyperventilation= CO₂ = H⁺ = pH = Alkalosis Hyperventilation= CO₂ = H⁺ = pH = Alkalosis Fig. 2: Respiratory regulation of blood pH.

Simple act of breathing also regulates blood's pH.. When the ventilation rate increases, more CO₂ will be excreted, leading to decreased H⁺ concentration and raise in pH. Contrarily, when the ventilation rate decreases, less carbon dioxide will get excreted, leading to its accumulation, therefore increase in H⁺ and decrease in blood's pH (Tortora, Derrickson, 2009, p. 1002). As we can see, lungs and brain control blood's pH minute by

minute. When the respiratory system fails to control the pH of the blood through ventilation it can lead to respiratory acidosis or alkalosis.

Respiratory acidosis is an excess of carbonic acid that is caused by conditions resulting in hypoventilation and CO₂ retention. The major effect of acidosis is depression of the central nervous system (Disney, 2002, p. 281). When the pH of the blood falls below 7.35, the central nervous system starts to malfunction, and the patient will become disoriented and possibly comatose as the condition worsens. Respiratory alkalosis occurs in case of deficit of carbonic acid caused by conditions resulting in alveolar hyperventilation and CO₂ deficit.

First, the peripheral nerves will be affected leading to spontaneous nervous stimulation of muscles (spasms) and extreme nervousness. Severe alkalosis can lead to death as a result of contraction of respiratory muscles (Disney, 2002, p. 283). Although in this essay I am concentrating on the role of the respiratory system in regulating the pH of blood it is worth mentioning the role of buffer and renal systems in their connection to the role of the respiratory system. Renal system is the slowest mechanism in regulating of the blood pH, however the only way to eliminate acids other than carbonic acid responsible for raise in the blood pH.

It helps to restore long term acid-base imbalance but is not quick enough to react in sudden changes (Powers, 2001, p. 312-313). The pH buffer systems are a combination of body's own natural weak acids and bases. They exist in balance under normal pH, however when any changes in pH solution occur, they change their proportions to chemically restore the balance (Appel, Downs, 2008). The important buffer systems include proteins, carbonic acid-

bicarbonate buffers and phosphates (Thomson, Adams and Crown, 1997, p. 53). Prolonged acid imbalances of any kind are not well tolerated by the body as they disturb its normal functions.

A chronically over-acidic pH corrodes body tissue and if left unchecked, it will interrupt all cellular activities and functions. The blood pH has a serious effect on all of the body's systems and that's why it is important for the body to maintain its acid-base balance, as even minor deviations from the normal range can severely affect every cell in our body. Due to close connection between the respiratory system and blood's acid-base balance any malfunctions of the respiratory system will lead to blood pH imbalances.

Word Count: 1099 SCENARIO 2 (1000 words)

With reference to negative feedback loops explore the role of the pancreas in glycaemic homeostasis. PLEASE TYPE YOUR ANSWER BELOW: Cells need a stable environment in order to survive. Negative feedback is the mechanism by which our body maintains its conditions at a homeostatic level (Guyton, Hall, 2006, p. 861). When the conditions exceed the above range of homeostasis, negative loop will release a hormone to bring those conditions back to normal. Contrarily, when the conditions exceed the lower range of homeostasis, the production of the second hormone will be triggered.

Negative feedback loop requires a receptor, a control centre and an effector. Located in the body are eight major endocrine glands that secrete hormones. Blood glucose concentration regulation through the negative feedback shows, how the endocrine system maintains the homeostasis within our body using two antagonistic hormones: insulin and glucagon (CliffsNotes, no date), released in the pancreas. In this essay I will explore what is glycaemic

<https://assignbuster.com/respiratory-system-and-maintaining-blood-ph/>

homeostasis and why is it essential for the health of cells and therefore for the health of the entire body.

I will find out how is it maintained within our body by the negative feedback loops and what is the role of the pancreas in this process. Glucose is the main source of energy for majority of cells in the human body (Tortora, Grabowski, 2006, p. 614). Its molecules are broken down in the cells to produce adenosine triphosphate (ATP) molecules, which provide energy for many cellular processes. Circulating blood delivers glucose molecules to cells and therefore the constant supply of glucose is reliable on the glucose levels being maintained at continuous and adequate level.

However, it is equally important, that the concentration of glucose in the blood and tissues is not excessive (Paul, 1999). The homeostatic level of glucose is achieved through the negative feedback systems of endocrine system which ensure that the glucose concentration is maintained within the normal range of 70 to 110 milligrams of glucose per decilitre (Paul, 1999). In a healthy person the homeostatic glucose levels are restored by one of the organs of the endocrine system- the pancreas. Fixed firmly in the pancreas is a large of endocrine tissue called the islets of Langerhans.

Simpkins and Williams (2001, p316) suggest, that the islets contain two types of cells- α - and β - cells, are responsible for the production of glucagon and insulin. Tissues use glucose at different rates, depending on the metabolic activity (Simpkins, Williams, 2001, p. 317). More glucose would be used by our body during exercise than during the rest time. The concentration of glucose will also rise after a meal, when the nutrients are being absorbed. After the glucose enters the bloodstream

(following food digestion), the β cells detect that the blood glucose concentration has raised and release the enzyme- insulin (Tortora, Derrickson, 2009, p. 340-341). Insulin has several functions. One of them is accelerating the conversion of glycogen from glucose. Blood leaving the gut contains the absorbed products of digestion and then passes them to the liver. The liver cells contain enzymes controlled by insulin, which help to synthesize the glycogen, the polymer of glucose. Glucose absorbed from the gut is stored in a form of glycogen in the liver and some of the skeletal muscles (Simpkins, Williams, 2001, p. 316).

Glucagon has the opposite role to the insulin. It stimulates the transformation of glycogen to glucose (Guyton, Hall, 2006, p. 861). The other functions of insulin include speeding up the entry of glucose from the blood into the respiring cells, increasing the cellular rate of glucose utilization as an energy source and stimulating of the fat synthesis from glucose in the liver cells (Paul, 1999). All these effects would together cause the decrease in the blood glucose concentration and the insulin secretion discontinuation (from negative feedback from declining levels of glucose).

Contrarily, when the blood glucose concentration decreases (for example during starvation), the pancreas will respond by stopping the insulin secretion and stimulating the alpha cells to secrete glucagon. Apart from accelerating the breakdown of glycogen to glucose, it increases the breakdown of fats to fatty acids and glycerol in adipose tissue as well as it stimulates liver cells to increase the synthesis of glucose from glycerol absorbed from the blood (Paul, 1999).

These effects will cause an increase in blood glucose level and the secretion will discontinue when reaching the homeostatic level (negative feedback). Blood glucose concentration declines Blood glucose concentration declines Blood glucose concentration rises Blood glucose concentration rises Pancreas stimulates alpha cells to release glucagon Pancreas stimulates alpha cells to release glucagon Pancreas stimulates beta cells to release insulin. Pancreas stimulates beta cells to release insulin. Increased breakdown of glycogen to glucose

Increased breakdown of glycogen to glucose Homeostasis- normal blood glucose level Homeostasis- normal blood glucose level Increased rate of glucose transport to the cells Increased rate of glucose transport to the cells Increased breakdown of fats to fatty acids Increased breakdown of fats to fatty acids Increased rate of glucose utilization Increased rate of glucose utilization Increased breakdown of protein to amino acids Increased breakdown of protein to amino acids Increased conversion of glucose to glycogen Increased conversion of glucose to glycogen

Increased protein synthesis Increased protein synthesis Increased synthesis and release of glucose Increased synthesis and release of glucose Increased fat synthesis Increased fat synthesis Blood glucose concentration rises Blood glucose concentration rises Blood glucose concentration decline Blood glucose concentration decline Fig. 1: The homeostatic regulation of blood glucose concentration via the negative feedback loop. In relation to negative loop system, the glucose transporters that bind glucose are the receptors. The α - and β cells act as the control centres, as by processing the information from the receptors they act by releasing effectors- insulin and

glucagon- in order to restore the internal conditions back to their normal level (Haaland, 2001). Maintenance of glycaemic homeostasis is crucial, as glucose is the only nutrient that can be used by brain to supply it with energy required for its functioning (Guyton, Hall, 2006). Contrarily, raised glucose concentration can produce a large amount of osmotic pressure in the extracellular fluid and lead to cellular dehydration.

High glucose concentration will also cause loss of glucose in the urine, which can deprive body of its fluids and electrolytes. Long-term increases in blood glucose may cause damage to many tissues, especially blood vessels and can lead to heart attack, stroke, blindness and renal diseases. Any disturbances in the glucose levels will be an indication of disease. For example, raised glucose levels would be present in diabetes mellitus, Cushing's syndrome, liver disease and hyperthyroidism. Contrarily, decreased glucose levels are present in Addison's disease, hypoparathyroidism and hypothyroidism (Paul, 1999).

The most common of all aforementioned diseases is diabetes mellitus. In type 1 diabetes body's immune system attacks and destroys the beta cells in the pancreas. This means that pancreas is unable to secrete insulin (Tortora, Derrickson, 2001, p. 341). People affected by the disease will need external source of insulin in order to survive. Type II is the most common type of diabetes. In this disease insulin secretion is not reduced, however the tissues in the body become resistant to insulin over time. Person affected by type II diabetes can control their glucose levels with the medication and the right diet.

Glucose is needed for the cells to function. Pancreas has a major role in maintaining right glucose levels as it is responsible for secretion of two antagonistic hormones responsible for the glucose regulation. Negative feedback loop stimulates the pancreas to release the right hormone at the time to bring the blood glucose to its homeostatic level. Any disturbances in the secretion of aforementioned hormones can lead to many diseases and body dysfunctions. Any pancreas malfunction will automatically lead to blood glucose level disturbances. Word count: 1098

PLEASE TYPE YOUR REFERENCE LIST BELOW: Appel, S. , Downs, Ch. , (2008) ‘ Understanding acid-base balance’. Nursing. 38 (9), pp9-11. CliffsNotes Antagonistic Hormones. [online] Available at: [http://www. cliffsnotes. com/study_guide/topicArticleId-277792, articleId-277669. html](http://www.cliffsnotes.com/study_guide/topicArticleId-277792, articleId-277669. html) (no date) (Accessed 11 Jan 2013). Disney, J. (2002) Acid-base disorders. In: Marx, J. et al. Rosen’s Emergency Medicine: Concepts of Clinical Practice. 5th ed. Oxford: Elsevier. Esmond, G. , (2001) Respiratory Nursing. London: Bailliere Tindall. Gregorie, L. , Gallagher, P. 2004) Life Sciences: Anatomy and Physiology for Health Care Professionals. Edinburgh: Nelson Thornes Limited. Guyton, A. C. , Hall, J. E. (2006) Textbook of medical physiology. 11th ed. London: Elsevier. Haaland, W. (2001) Homeostasis. [online] Available at: [http://www. bioedonline. org/slides/slide01. cfm? tk= 25](http://www.bioedonline.org/slides/slide01.cfm? tk= 25) (Accessed 16 January 2013). Hinchliff, S. M. , Montague, S. M. , Watson, R. (2005) Physiology for Nursing Practice. 3rd ed. London: Elsevier. | | | Jupiterionizer, 2004. Are you overly Acidic? [online] Available at: [http://www. jupiterionizer. com/are_you_overly_acidic. htm](http://www.jupiterionizer.com/are_you_overly_acidic. htm) (Accessed 02 January 2013). Marino, P. , Sutkin, K. , (2006) Acid-base interpretations. 3rd ed. [e-book] Lippincott

Williams & Wilkins. Available at: Scribd. > <http://www.scribd.com/doc/35400593/The-ICU-BOOK-Paul-Marino-Complete> < (Accessed 3 January 2013). Paul, I. (1999) Blood sugar regulation. [online] Available at: <http://www.biologyreference.com/BI-Ce/Blood-Sugar-Regulation.html> (Accessed 09 January 2013). Powers, A. (2001). Acid-Base Balance. In: Curley, M. , (2001). Critical care nursing of infants and children. nd ed. Michigan: Elsevier. pp. 309-321. Reid, J,. (2011) Understanding acid/alkaline balance. [pdf] Manchester: Integrative Complementary Wellness Centre. Available at: http://www.byregion.net/images/pdfs/1019_9.pdf (Accessed: 06 January 2013). Simpkins, J, Williams, J. I. (2001) Advanced Human Biology. London: Collins Educational. Sheldon, L. (2001) Oxygenation. Thorofare: Slack. Tortora, G. , Derrickson, B. (2009) Principles of Anatomy and Physiology: Maintenance and Continuity of the Human Body. 12th ed. Volume 2. Hoboken: Wiley. Tortora, G. , Grabowski, S. 2006) Principles of Anatomy and Physiology. 10th ed. Hoboken: Wiley. Thomson, W. , Adams, J. , Cowan, R. , (1997) Clinical Acid-Base balance. Oxford: Oxford University Press. Triplitt, C. L. (2012) ' Understanding the mechanisms to maintain glucose homeostasis: A review for managed care'. The American Journal of Managed Care, 18(1), pp. 4-27. [Online] Available at: <https://secure.pharmacytimes.com/lessons/pdf/201201-02.pdf> (Accessed 09 January 2013). Waugh, A. , Grant, A. , (2010) Ross and Willson: Anatomy and Physiology in Health and Illness. 11th ed. London: Elsevier.