Bicarbonate system in the blood research paper examples

Environment, Water

Regulation of body pH occurs either through pH regulation or pH compensation. Regulation occurs as a combined effort of buffer systems, and respiratory and renal systems. Normal metabolism produces acidic wastes, for example, carbonic and lactic acid. These products increase acidity of body fluids and cause a shift in body pH away from the normal alkaline nature. Buffers help to prevent the shift towards an acidosis, and hence maintain pH of the blood and the body. Buffers also facilitate maintenance of narrow pH ranges of body fluids. Maintenance of this narrow range is crucial since biochemical reactions are affected by concentration of hydrogen ions. The optimum pH for different enzymes varies from one enzyme to another.

A buffer comprises of a weak acid and its conjugate base. These components are responsible for resistance to changes in pH due to addition in hydroxyl or hydrogen ions. The bicarbonate-carbonic acid buffer system is one of the body's buffering systems. This system is functional in extracellular fluids. Another buffering system is the hemoglobin buffer system which operates in the red blood cells. Other buffer systems include the protein buffer system in blood plasma and cells, and the phosphate buffer system that operates in all cells.

Protein Buffer System

This buffer system is mostly used in blood plasma and in cells. Amino acids are made up of a carboxyl group and an amine group. The carboxyl group can donate ions to the amine group and hence function as an acid. Similarly, the amine group acts as a hydrogen ion acceptor. The resulting compound when the two groups combine, referred to as a zwitterion, functions as a buffer. Excess hydrogen ions can easily combine with the amine group, hence maintain the pH. Hydrogen ions are released from the amine group when there are excess hydroxyl ions. This results in formation of water that is easily excreted.

The bicarbonate buffer system

Carbon (IV) oxide is a major source of metabolic acids in the body. The bicarbonate buffer system is crucial in the regulation of pH changes due to changes in carbon dioxide levels. Upon reaction with water, CO2 forms weak carbonic acid. Carbonic acid can dissociate into hydrogen ions and bicarbonate anion (HCO3). Carbonic acid, usually referred to as a volatile acid, constitutes CO2 and water vapor that can be easily discharged from the body through the lungs. Lactic acid is non- volatile and is discharged through the kidneys. Most of the body’s carbon dioxide is circulated as bicarbonate ions due to the bicarbonate buffer system. The alkaline ion can accept hydrogen ions to become carbonic acid (Hinwood, 81).

Carbonic acid is a weak acid. This means it does not easily release hydrogen ions. Removal of most of the hydrogen ions from body fluids enables these fluids to retain their original pH. When hydroxyl ions are added to blood, carbonic acid combines of these ions to form bicarbonate ions. Consequently, the blood retains its original pH due to removal of excess hydroxyl ions. Excess carbonic acid can easily dissociate into water and carbon dioxide. These two compounds are removed from the body (blood) through the lungs. The metabolic reactions in the body have a tendency of acidifying the blood. This means more bicarbonate ions are required as compared to carbonic acid concentration (Hinwood, 85).

The required concentration of carbonic acid to bicarbonate ions concentration, in moles per litre, is approximately one to twenty. These concentrations will then vary depending on the proportionate changes of the pH of blood. If the carbonic acid concentration increases, the pH also increases due to increase in acidity. Bicarbonate ions are usually administered to patients whose blood is very acidic. This returns the carbonic acid to bicarbonate ions ratio to the necessary 1: 20. A buffering reaction involves the increase in the concentration of one of the compounds in the buffer pair and a corresponding decrease in the other. Bicarbonate ions react with hydrogen ions and hence reduce acidity while carbonic acid reacts with hydroxyl ions to give carbon dioxide and water.

The bicarbonate system works closely with hemoglobin in the red blood cell in maintaining the pH of blood over a narrow range. This means that the respiratory system plays a crucial role in buffering of blood. The hypothalamus houses the respiratory centre that is responsible for control of the breathing rate. The rate of breathing increases with a decrease in pH. This is due to the decrease in the concentration of carbon dioxide (Lieberman et. al, 31).

Blood pH and Ventilation

Hyperventilation is the increased rate of breathing due to CNS disorders such meningitis, cerebral hemorrhage or drug-induced hormonal changes. This may lead to very low level of carbon dioxide; lower than is required. As carbon dioxide levels decrease due to excessive exhalation, the concentration of carbonic acid and hence hydrogen and bicarbonate ions decreases. This results in a rapid increase in blood pH with a maximum pH being attained within fifteen minutes. The rapid rise in plasma pH is referred to as respiratory alkalosis. Hypoventilation is the inability of the body to excrete carbon dioxide rapidly. It may occur due to use of narcotics, aesthetics and other depressant drugs. This may result in respiratory acidosis (Kumar, 207).

Acidosis

This occurs as either metabolic acidosis or metabolic acidosis. Metabolic acidosis is caused by the deficiency in bicarbonates (Kumar 207). Deficit in the bicarbonates reduces the pH resulting to metabolic acidosis. One way through which this can occur is through primary compensatory mechanism, which leads to carbon dioxide loss and reduction in bicarbonates. Common causes of metabolic acidosis include excessive production of acid ions due to starvation, shock, diabetic acidosis, increased fever, anoxia, and lactic acidosis (Kumar 208).

Respiratory Acidosis

This condition is mainly characterized by an excessive concentration of carbonic acid. It occurs due to impairment of excretion of carbon dioxide through the lungs. Carbon dioxide then accumulates in the blood resulting in excessive formation of carbonic acid. For instance, any impairment of carbon dioxide excretion form the lungs results to an increase in accumulation of carbon dioxide in the blood and this contributes to excess formation of bicarbonates (Kumar 209). The ratio of bicarbonate ions to carbonic acid concentration is hence lowered. Consequently, the pH decreases. The compensatory mechanism is usually through hyperventilation so as to achieve a reverse effect. Alternatively, bicarbonate ions may be reabsorbed from the renal tubules so as to restore the bicarbonate ions to carbonic acid concentration ratio to the ideal 20: 1. The condition may be caused as an effect of excessive pain, pneumonia, asthma, congenital heart diseases, pulmonary edema or brain damage. Respiratory acidosis is caused due suppression or depression of respiration because of drug poisoning, effect of pain, brain damage and due to loss of ventilator function.

Metabolic Acidosis

This condition is mainly due to a deficiency in the bicarbonate ions. Such a deficit decreases the bicarbonate to carbonic acid concentration ratio. This increases the pH and results in metabolic acidosis. The condition may result in kussmaul breathing so as to reduce the carbon dioxide level in blood. The condition is usually a consequence of increased acid ion concentration due to starvation, fever, lactic acidosis or respiratory acidosis (Kumar, 211). Another cause is renal insufficiency, which is partial kidney failure that causes reduced production of wastes.

Metabolic acidosis can also be caused by the ingestion of acidifying salt such as phosphoric acid, hydrochloric acid, and acetyl salicylic acid. In addition, abnormal loss of bicarbonates via vomiting or diarrhea also causes metabolic acidosis. An important concept in acidosis is the anion gap, which refers to the unmeasured anions, that is, the difference in anions and cations measured in the serum (Kumar 208). The anion gap increase during acidosis and is very useful in clinical assessment of patients with acid-base disorders.

Alkalosis

This occurs as both metabolic alkalosis and respiratory alkalosis. Metabolic alkalosis results from the presence of excess bicarbonate anion (HCO3). This excess accumulation of the bicarbonate anion causes an elevation of the pH levels (Kumar 210). Common causes of metabolic alkalosis include alkali ingestion and alkali administration, deep X-ray therapy or prolonged exposure to UV radiation, severe vomiting that causes loss of acids and hyperaldosteronism, which causes retention of sodium and loss of potassium resulting to hypokalemia (low amount of potassium in the blood) (Kumar 210).

Respiratory alkalosis results from the deficiency in carbonic acid resulting to an increase in pH. This is caused by stimulation of the respiratory center due to hyperpyrexia, salicylate poisoning, and due to diseases such as meningitis. Furthermore, it can be caused by hepatic coma, injudicious use of respirator, high altitude effect and by apprehensive blood donors (Kumar 211).

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