Vetamac Vapors

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The next two or three issues of Vapors will discuss the removal of carbon dioxide from the anesthetic breathing circuit. If you find these discussions helpful or if you have questions, please email us at info@vetamac.com. If you would like to read past issues, those may be accessed on our website, www.vetamac.com.

Carbon Dioxide Removal Part I

Failure to remove exhaled carbon dioxide from the breathing circuit results in increased carbon dioxide in the blood. This produces a respiratory acidosis as well as an increase in respiratory rate. Both conditions are detrimental to a successful anesthetic procedure.

This issue will discuss the chemical absorption of carbon dioxide in the rebreathing anesthetic circuit. This process utilizes the principle of a base neutralizing an acid. The expired carbon dioxide reacts with water to form carbonic acid which in turn is neutralized by the alkaline chemicals in the absorbent. The end products of this reaction are water and a carbonate.

The most common absorbent is soda lime. By weight it is 4% sodium hydroxide, 14-19% water and enough calcium hydroxide to make 100%.[1] A small amount of pH sensitive dye is also added. As the absorbent reacts with carbon dioxide, the color changes to purple indicating that the absorbent is exhausted.

The water in the absorbent is present as a thin film on the granule surface. This water is necessary for the chemical reaction that takes place between the carbon dioxide and the absorbent. The high moisture absorbents (14-19%) have a slower rate of absorption and do not exhaust as rapidly as low moisture absorbents. The humidity of the breathed gases does not affect the capacity of the soda lime to absorb carbon dioxide.[2]

The absorption of carbon dioxide takes place by the following chemical reactions:

$$CO_2 + H_2O \leftrightarrow H_2CO_3$$

Carbon dioxide is hydrated to form carbonic acid.
This weak acid is then completely dissociated into it's ions.

$$H_2CO_3 \leftrightarrow H^+ + HCO_3^- \rightarrow H^+ + CO_3^{-2}$$

The sodium hydroxide and calcium hydroxide are also dissociated into their ions:

$$NaOH \leftrightarrow Na^+ + OH^-$$
$$Ca(OH)_2 \leftrightarrow Ca^{2+} + 2OH^-$$

Finally, the sodium and calcium ions combine with the carbonate ions to form sodium carbonate and calcium carbonate:

$$2Na^+ + CO_3^{-2} \rightarrow Na_2CO_3$$

$$Ca^{2+} + CO_3^{-2} \rightarrow CaCO_3$$

This chemical reaction is exothermic meaning that heat is released as the reaction takes place. This heat can be detected on the outside of the canister. If heat is not present this may mean that absorption is not taking place. The amount of carbon dioxide absorption is about 26 liters/100 grams of absorbent. Efficiency may vary depending on the design of the canister and the method of packing.[3] If the absorbent is working properly there should be a negligible amount of carbon dioxide being rebreathed by the patient.

The next issue will discuss different situations that may compromise the efficiency of the absorbent.

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1. Dorsch JA, Dorsch SE. Understanding Anesthesia Equipment, 4th Edition: Williams and Wilkins, 1999.
2. Miles G, Adrian J. Carbon Dioxide Absorption. Anesth Analg 1959; 38:293-300
3. Thurmon JC, Tranquilli WJ, Benson GJ. Lumb and Jones Veterinary Anesthesia, 3rd Edition: Lippincott Williams and Wilkins 1996

FAQs

Q: Why doesn't the absorbent ever turn purple?

A: It is possible that if the oxygen flow rate is high enough and the pop-off valve is located close to the expiratory one way valve, that some of the carbon dioxide is being removed through the pop-off valve instead of the absorbent.

If you have a question you would like answered in our FAQs, please email us at info@vetamac.com.