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SAFE ADMINISTRATION OF BICARBONATE

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INTRODUCTION

Bicarbonate (HCO₃⁻) is a strong alkalinizing agent most commonly available as sodium bicarbonate. The primary indications for bicarbonate administration are metabolic acidosis, hyperkalemia and to aid the excretion of specific toxins. The following discussion addresses the issues of bicarbonate administration.

Sodium bicarbonate has five significant effects that may cause harm to a patient.
1. Binding of ionized calcium
2. High osmolality
3. High sodium concentration
4. Acid base changes
5. Lowering of serum potassium concentration

1. Ionized Calcium: Changes in pH alter the affinity of ionized calcium for albumin. Increases in pH in response to bicarbonate administration will increase the binding of ionized calcium on albumin. Rapid bicarbonate administration can cause a life threatening decrease in serum ionized calcium leading to cardiovascular collapse. For this reason bicarbonate should never be bolused (except during cardiopulmonary resuscitation). Bicarbonate administration should be given as an infusion over 20 – 30 minutes or longer.

2. Osmolality: Osmolality is in equilibrium across intracellular and extracellular compartments. This osmolality is a product of the concentrations of the major osmotically active substances, namely sodium, chloride, glucose and blood urea nitrogen. Normal serum osmolality is 290 - 310 milliosmoles for dogs and 290-330 milliosmoles for cats. Changes in serum osmolality will result in movement of water and subsequent changes of intracellular volume. The cells most sensitive to these volume changes are brain cells. Rapid increases in serum osmolality will increase blood volume and cause cell shrinkage. This can have serious and possibly life threatening ramifications.

Sodium bicarbonate is generally formulated as a hyperosmolar solution, the high osmolality is primarily a consequence of the high sodium concentration. A common formulation is 8.4% sodium bicarbonate, this is 1mEq/ml of NaHCO₃ and has an osmolality of 2200? mOsm. This hyperosmolality makes NaHCO₃ a very unfriendly solution to work with. Solutions with osmolalities of > 600 mOsm should not be administered through a peripheral vein as they can quickly cause phlebitis and possibly thrombosis. It can be given undiluted into a central vein such as a jugular vein or caudal vena cava. If administered in this manner it should be given slowly to prevent rapid changes in serum osmolality. Diluting bicarbonate to make it iso-osmolar (~300 mOsm) makes it a much more user friendly solution. Dilution with a sodium free solution such as 5% dextrose (D5W) or sterile water is simplest. A 1:6 dilution of the 8.4% sodium bicarbonate with D5W will produce a solution of an osmolality of ~ 300 mOsm. For example 50ml of 8.4% NaHCO₃ would need to be diluted with 300ml of D5W. If a different strength solution of NaHCO₃ is used a different ratio for dilution will be required.

3. High Sodium Concentration: The high sodium concentration effectively makes NaHCO₃ a form of hypertonic saline and as such it is a potenct volume expander. If given undiluted it will cause movement of water out of cells and into the interstitial and intravascular space. The result is cell shrinkage and vascular volume expansion. Before administration of sodium bicarbonate, the patients ability to cope with an increase in blood volume should be ascertained. Sodium bicarbonate should be administered with extreme caution if at all to at risk animals such as those with congestive heart failure or anuric renal failure.

4. Acid Base Changes: The primary indication for bicarbonate administration is to treat a metabolic acidosis. Over treatment with bicarbonate will produce a metabolic alkalosis which can be as detrimental as an acidosis. The general approach to bicarbonate dosing is to be conservative. The aim is to return pH back towards normal but not to make pH completely normal to avoid an iatrogenic alkalosis. Maintaining a minimum pH of 7.2 is sufficient.

When bicarbonate is buffered in the body carbon dioxide (CO₂) is released. Normally this is rapidly excreted by the lungs. Patients with respiratory compromise or poor tissue perfusion may not clear CO₂ from the body effectively and it may create an intracellular acidosis. This can be detrimental to cell function and negate the benefits of bicarbonate therapy. This is of particular concern in patients that cannot tolerate increases in intracranial pressure.

5. Lowering of Serum Potassium: The administration of bicarbonate will lead to a movement of hydrogen ions from the intracellular space to the extracellular space to buffer the bicarbonate. In exchange for these hydrogen ions there is an intracellular shift of potassium ions resulting in a reduction in serum potassium. For this reason bicarbonate is often utilized for the therapy of hyperkalemia. In animals with normal or low serum potassium levels bicarbonate administration can cause detrimental reductions in serum potassium. Careful monitoring of serum potassium is important in patients receiving bicarbonate therapy.

DOSE

If it is determined that a patient will benefit from bicarbonate therapy, administration of the appropriate dose will help minimize the adverse effects. There are several ways in which the dose of bicarbonate can be estimated, none of them are exact in nature. One such approach is described here.

1. The clinician determines how much they wish to increase the serum bicarbonate. For example if a patient has a serum bicarbonate of 4 mEq/L and the clinician wishes to increase it to 12 mEq/L then the desired increase is 8.

2. Dose of bicarbonate in mEq = Desired increase in bicarbonate x body weight (kg) x 0.3

3. The entire calculated bicarbonate dose is administered

REFERENCES:


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