Sodium Bicarbonate

Intuitively, sodium bicarbonate would seem to be an ideal agent for treating acidosis. But there are some surprises.

The Na+ in NaHCO3 is beneficial since it increases the plasma Na+ concentration which increases the strong ion difference, increasing pH.

The HCO3- in NaHCO3 is potentially a big problem since it can be the source of large amounts of CO2 according to

[H+] + [HCO3-] 🡨🡪 CO2 + H2O

If NaHCO3 is added to a closed system, the beneficial effects of Na+ are offset by the CO2 generated and the pH doesn’t change much (2).

While a closed system may seem far removed from the clinical management of acid / base disorders, I cite 2 examples to the contrary. Both involve impaired respiratory elimination of CO2, making the body a good approximation to a closed system.

Any disorder that impedes the respiratory elimination of CO2 will probably cause respiratory acidosis and blunt the therapeutic effect of sodium bicarbonate by impeding the elimination of the newly generated CO2. Respiratory distress syndrome in newborn infants is an example.

In another example, a patient in cardiac arrest was intubated for ventilation, given cardiac massage, and given an IV injection of NaHCO3 (3). Unfortunately, the endotracheal tube was placed in the esophagus, effectively making the patient a closed system. Arterial pCO2 was 194 mmHg before the NaHCO3 injection and rose to 280 mmHg after it.

The effectiveness of NaHCO3 injection depends on a venous injection site and adequate ventilation to quickly eliminate some of the newly generated CO2. Still, some of this CO2 passes through the pulmonary circuit into the systemic arteries (1,3). This CO2 will *decrease* the pH in brain (4) which is not the desired outcome when acidosis is being treated.

On the positive side, lower cerebral pH stimulates respiration and this helps to blow off the extra CO2. The overall respiratory response, then, is an early increase in ventilation caused by CO2 followed by a later depression of respiration caused by the alkalosis (1).

The Sodium Bicarbonate Protocol

We can see the effects described above by giving a rapid IV NaHCO3 infusion to a normal subject.

Click Restart to reestablish initial conditions. Record control values. Go to  **IV Drip**. Create an IV drip that delivers 500 mMol of NaHCO3 over 10 minutes. Advance time 5, 10, 15 and 20 minutes and observe the effect of the infusion on acid / base balance, respiration and brain pH.

|  |  |
| --- | --- |
|  | Venous pH  Venous pCO2 (mmHg)  Arterial pH  Arterial pCO2 (mmHg)  Brain pH |
|  |  |
|  | Total Ventilation (L/Min) |
|  |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Time (Min) | 0 | 5 | 10 | 15 | 20 |
| Venous pH | 7.36 | 7.28 | 7.36 | 7.51 | 7.52 |
| Venous pCO2 | 46 | 71 | 72 | 51 | 50 |
| Arterial pH | 7.40 | 7.38 | 7.44 | 7.53 | 7.54 |
| Arterial pCO2 | 41 | 56 | 60 | 48 | 47 |
| Brain pH | 7.01 | 6.98 | 6.99 | 7.04 | 7.05 |
| Ventilation | 6.8 | 14.8 | 11.9 | 4.5 | 4.5 |

References

1. *J. Clin. Invest.* 35:245, 1956.
2. *J. Pediatric.* 80:671, 1972.
3. *J.A.M.A.* 235:506, 1976.
4. *Am. J. Physiol.* 25:H1316, 1989.