Normalization of Uremic Acidosis in Hemodialysis Patients With a High Bicarbonate Dialysate

To the Editor:

Oettinger and Oliver (1) have introduced a confusing new medical semantic to the field of acid-base chemistry. In traditional acid-base chemistry, the addition of 3 mmol of acid (acetic acid) to 36 mmol of base (sodium bicarbonate) yields 33 moles of base and 3 moles of neutral salt. In this report, such a reaction yields 39 mmol of base ("Standard bicarbonate"). This presumes that the freshly generated sodium acetate will act as a base equivalent through metabolic pathways and that the CO$_2$ gas produced in the acetic acid–sodium bicarbonate reaction will become an electron donor rather than be expelled via ventilation.

Dialysis using a dialysate bicarbonate of 35 to 37 mmol has been described (2, 3), and in those analyses, the concentrates have contributed 40 mmol of sodium bicarbonate and 3 or 4 mmol of acetic acid to each liter of dialysate. Patients using this dialysate (some for over 8 yr) have corrected their uremic "hyperbicarbonatemia" but still have an expanded anion gap (suggesting a continued uremic acidosis). Further, the composition of the "high-bicarbonate" dialysate is somewhat atypical. First, the desired pH of the bicarbonate dialysate is between 6.9 and 7.2; higher readings guarantee the formation of calcium and magnesium carbonates in the dialysate and diminish calcium delivery. Thus, although serum-ionized and total calcium do not change, it is likely that this dialysate composition (less than 2.5 mEq/L calcium) will accentuate the development of osteopenia. Second, the Henderson-Hasselbalch equation needs to be applied correctly to the medium, either saline or blood. In this instance, the dialysate pH and PCO$_2$ are indicative of a bicarbonate content of 37 mmol rather than the reported total carbon dioxide combining power of 42 mmol.

Busy clinicians often lack administrative control over their dialysis unit and cannot perform routine quality assurance measurements on dialysis components. For this reason, it is important that clinical articles be eminently lucid and carefully reviewed before they become therapeutic guidelines. Drs. Oettinger and Oliver should be commended on their presentation, but the reviewers should have insisted on a clarification of the total carbon dioxide combining power of the dialysate, a chemistry concept that I find confusing.

Michael Flanigan
Department of Medicine
University of Iowa Hospitals
Iowa City, IA

REFERENCES


Reply

We appreciate the opportunity to respond to Dr. Flanigan's comments and questions. As with all commercial "standard" bicarbonate dialysates for the equipment used in this study, the bicarbonate concentrate contains 39 mEq of sodium bicarbonate per liter. After dilution with acid concentrate containing 3 mEq of acetic acid per liter, the final dialysate yields the concentrations stated in the article of 36 mEq of bicarbonate and 3 mEq of acetate per liter. The CO$_2$ gas generated by this reaction is usually considered to be ventilated, whereas the acetate is available for consumption via the Krebs cycle with a concomitant reduction in H$^+$ concentration. This is the principle that has used acetate as the sole buffer in dialysate for years. It should be noted that the composition of high bicarbonate is stated as the final dilution and that we started with a bicarbonate concentrate of 42 mEq/L before acidification.

We would agree that some patients do correct predialysis serum CO$_2$ with standard bicarbonate. With the use of high bicarbonate, 75% of our study population, some of whom had also been on standard bicarbonate since 1985 without a normal predialysis CO$_2$, achieved a serum CO$_2$ of 23 mEq/L or higher without progressive alkalemia. We are skeptical of the statement that bicarbonate dialysate should have a pH of 6.9 to 7.2. Numerous studies, including Dr. Flanigan’s, report a bicarbonate dialysate pH of more than 7.3 (1–3). The use of the Henderson-Hasselbalch equation is an estimate, whereas the addition of sodium bicarbonate used in the manufacturing of