Prevention of Contrast-Induced Nephropathy with Sodium Bicarbonate: Randomized Trial of Hydration Fluids

Jeremiah H. Holleman, MD, Charlotte, NC; Gregory J. Merten, MD; W. Patrick Burgess, MD, PhD

Background

Contrast-induced nephropathy remains a common complication of radiographic procedures. Consistent evidence of benefit in the face of preexisting renal insufficiency has been shown only by pretreatment hydration with saline, nonionic contrast, low- or iso-osmolar contrast, and smaller volumes of contrast. Prophylactic use of the free radical scavenger, N-acetylcysteine has shown benefit in some studies and in a recent meta-analysis, supporting the hypothesis that contrast-induced renal failure is a result of free radical generation. We hypothesized that low renal tubular pH contributes to free radical formation and renal failure from contrast. Thus, NaHCO3 should be superior to NaCl in preventative hydration. All prophylactic protocols to prevent contrast-induced nephropathy include the infusion of sodium chloride (NaCl) either alone or with other agents. However, in prophylactic hydration to combat contrast-induced nephropathy, it is possible that the most efficacious anion for sodium is not chloride (Cl), but bicarbonate (HCO3). As a consequence of the kidney's role in excreting inorganic acids, urine is usually acidic, creating a setting that may facilitate free-radical mediated injury. Free radical formation in human tissue is subject to the biochemical milieu: promoted by an acidic environment, and reduced by an environment with the pH of normal extracellular fluid. Since a postulated mechanism of contrast-induced nephropathy is oxidant damage by free radicals, attempts to alkalinize renal tubular fluid may reduce renal injury.

Method

The objective was to examine the efficacy of NaHCO3 compared to NaCl for preventative hydration before and after contrast. The design involved a prospective, open, randomized infusion of 154 mEq/L NaCl versus NaHCO3 with serum creatinine levels measured at baseline, 24 and 48 hours after contrast. Between September 2002 and June 2003, 118 patients at a single center with serum creatinine
? 1.1 mg/dL were randomized to receive either NaHCO3 (n = 60) or NaCl (n = 58) before and after iopamidol (370 mg iodine/mL). Patients received either NaCl or NaHCO3, 154 mEq/L, as a bolus of 3 mL/kg over 1 hour prior to contrast, followed by an infusion of
1 mL/kg/hr for 6 hours after the procedure. Contrast-induced nephropathy, defined as an increase of 25% or more in serum creatinine within 48 hours of contrast.

Results

There were no group differences in age, sex, incidence of diabetes, ethnicity, or contrast volume. Baseline serum creatinine (1.7 [0.3] mg/dL for NaCl; 1.9 [0.7] mg/dL for NaHCO3) was slightly but significantly higher in NaHCO3-treated patients (p = .036). The primary end point of contrast-induced nephropathy occurred in 13.8% of patients infused with NaCl but in only 1.7% of those receiving NaHCO3 (95% CI of the difference, 2.7–21.6%; p = .016). A follow-up registry of 106 patients receiving prophylactic NaHCO3 has resulted in one case of contrast-induced nephropathy (0.9%). A subsequent analysis of the NaHCO3 group stratified for eGFR has demonstrated that the incidence of renal failure following contrast exposure following pretreatment is independent of preprocedure renal function.

Conclusions

Hydration with NaHCO3, which requires just 1 hour preparation prior to contrast exposure, is more protective than NaCl for prophylaxis of contrast-induced renal failure.

References

1. Merten GJ, Burgess WP, Gray LV, et al. Prevention of contrast-induced nephropathy with sodium bicarbonate: a randomized controlled trial. JAMA 2004;291:2328–34.