Hydrochloric Acid for Treating Metabolic Alkalosis

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ABSTRACT: Six patients with severe metabolic alkalosis were treated with intravenous hydrochloric acid (HCl) infusion. HCl was given through a central venous catheter, at a concentration of 0.1 mEq per ml. At least two of the following criteria were considered for initiation of the therapy: An arterial pH of greater than 7.45, a base excess (BE) of greater than +7 mmol/L, a PaCO₂ of greater than 50 mmHg. The HCl amount was calculated using the BE formula, however, two thirds was infused for avoiding excessive acid loading. Patients were monitored by the blood gases, serum electrolytes, hemoglobin, hematocrit, bilirubin determinations and blood smear findings. While a significant decrease was noticed in pH and BE values, moderate changes were detected in PaCO₂ due to different ventilatory status of the cases. All laboratory test results remained within normal limits and no complication was encountered. The advantage of the therapy is that less volume is needed for the correction of alkalosis, particularly in the cases requiring fluid restriction. HCl therapy, moreover, is a safe and time-saving method because of having rapid response to the treatment in the critically ill surgical patients.

KEY WORDS: hydrochloric acid, metabolic alkalosis

INTRODUCTION

Although metabolic alkalosis is frequently encountered in critically ill patients, its clinical importance is not yet clearly understood. Even though this entity is less life-threatening than metabolic acidosis, its characteristics include complicated etiological factors and a difficult treatment mode.

Severe metabolic alkalosis may lead to serious physiological changes and ultimately death in critically ill patients. For this reason, one should be ready to start aggressive treatment immediately in such cases. The treatment of alkalemia is particularly important in patients who have developed cardiovascular disease or alveolar hypoventilation secondary to metabolic alkalosis.

PATIENTS AND METHODS

Six patients who developed metabolic alkalosis from various causes between January, 1986 and January, 1988, were given a total of 18,200 ml of 0.1 N hydrochloric acid (HCl) solution. Three of the patients were women and three were men and their mean age was 45 years.

Case 1 The cause of metabolic alkalosis in this patient was an excessive loss of gastrointestinal fluid. A high output duodenal fistula (2500 ml/day) had developed as a result of the breakdown of a Jaboulay gastroduodenostomy performed for a duodenal ulcer. A total 500 mEq of HCl was continuously infused over four days. The
initial level of PaCO₂ showed hypoventilation (52.3 mmHg) but it decreased to 35.1 mmHg after the treatment.

Case 2 This patient had a cardiac arrest whilst undergoing surgery for a liver abscess. A large amount of sodium bicarbonate (NaHCO₃) was administered during resuscitation, which led to metabolic alkalosis in the early postoperative period. A total 500 mEq of HCl was infused over four days and his pre- and post-treatment levels of PaCO₂ were within normal limits.

Case 3 This patient had severe peritonitis and sepsis. We had great difficulty in establishing the exact cause of her alkalemia, however, it could possibly have been sepsis alone. A total 350 mEq of HCl was given over three days and her PaCO₂ levels were normal during the course of alkalosis therapy.

Case 4 Extreme hypovolemia developed in this patient due to severe attacks of acute cholecystitis and gastroenteritis resulting from typhoid fever. After the correction of hypovolemia, cardiac failure developed and intensive diuretic therapy was commenced together with digitalization. Furosemid, 60 mg/day, was administered for 10 days and this regimen eventually caused metabolic alkalosis. After administering 150 mEq of HCl over 20 hours, the pH decreased to 7.52 from 7.56 and the BE to +5.8 mmol/L from +10 mmol/L. Unfortunately, however, this patient died of severe sepsis during the course of therapy. There was no proof of hypoventilation.

Case 5 The cause of alkalemia was iatrogenic in this patient. Prior to emergency surgery for an ileus caused by colon carcinoma, she had been given excessive NaHCO₃ because of her severe metabolic acidosis. Thus, 200 mEq of HCl was infused over two days. The PaCO₂ values displayed no sign of hypoventilation in this case.

Case 6 This patient underwent emergency surgery for a perforated gallbladder and peritonitis. He had been given an excessive amount of NaHCO₃ prior to his operation to correct severe acidosis. This iatrogenic alkalotic state was corrected using 120 mEq of HCl given over 24 hours. No sign of hypoventilation was noted and the PaCO₂ remained within normal limits.

The presence of at least two of the major criteria described below determined the need for HCl infusion in the above patients:

1) An arterial pH of greater than 7.45, 2) a BE of greater than +7 mmol/L, and 3) a PaCO₂ of greater than 50 mmHg.

HCl solutions were prepared in the Biochemistry Laboratory of the Numune Hospital using commercial HCl (Merck). 8.6 ml of commercial HCl with a density of 1.19 and a concentration of 37 per cent was added to 1000 ml of saline. The solutions were then given through a central venous line at a concentration of 0.1 mEq of HCl per milliliter.

The following formula was used to calculate the total HCl needed:

\[ \text{BE (mmol/L)} \times \text{Body weight (kg)} \times 0.3 \text{ (L/kg)} \]

Using this formula, only two thirds of the calculated amount was given in order to avoid acid overloading. All cases were monitored by measuring blood gases every six hours and changes required in the mode of the therapy were adjusted according to each patient's results.

Serum electrolytes, hemoglobin, hematocrit, total and indirect bilirubin values and blood smears were also constantly tested throughout the treatment period, including before and after the infusion.

Results were statistically evaluated using Student's t test.

RESULTS

The average amount of HCl given to the patients was 303.3 ± 70.1 mEq and the mean therapy period was 2.5 ± 0.6 days (mean ± SEM).

All the laboratory findings of the patients are shown in Table 1. The average values of pH, HCO₃⁻ and BE found in the blood gas determinations taken before the HCl infusion were as follows: