Fallibility of Measurement of Strong Ion Difference for Evaluation of Acid-base Status in Diarrheic Calves

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Abstract

Acid base balance has traditionally been described in terms of the Henderson-Hasselbach equation (pH, pCO_2, TCO_2). Strong Ion Difference (SID = $Na^+ + K^+ - Cl^-$) is a recent concept and purports to better describe and explain the mechanisms involved in acid base physiology.[1,2] Quantitative acid-base analysis utilizing the measurement of SID does not appear to have been utilized to any significant extent in human medicine[3,4] although it appears to be gaining credence in both clinical and experimental veterinary medicine as a means of describing acid-base status.[5] The objective of this study was to evaluate measurement of SID as a means of diagnosing and quantifying acid-base disturbances in naturally occurring cases of calf diarrhea.

Eighty-four cases of calf diarrhea were treated with fluids in a veterinary practice. Calves were blood sampled before, during and after therapy. An additional 13 apparently healthy calves of similar ages were sampled as controls. TCO_2 was measured in jugular venous blood using a Harleco apparatus.[6] Diarrheic calves were treated appropriately with either oral (ORT) (n = 31) or parenteral (IF) (n = 53) fluids. The ORT used was Electrolyte Double Plus (Vetquinol) yielding 118 mmol/l Na^+, 25 mmol/l K^+, 110 mmol/l glucose, 108 mmol/l HCO_3^- (as citrate),43 mmol/l Cl^-, 4 mmol/l Ca^{++}, 4 mmol/l Mg^{++} and 20 mmol/l glycine. The IF used was Electrolyte ED (Vetquinol) containing 144 mmol/l Na^+, 4 mmol/l K^+, 35 mmol/l HCO_3^- and 113 mmol/l Cl^-. Serial Harleco measurements were taken to assess the therapy. Metabolic acidosis was widespread and severe among the diarrheic calves, being more severe in the collapsed calves requiring IF. Treatment produced significant improvements in acid-base status as demonstrated by an increase in TCO_2. Treatment was successful in 27 of the 31 calves receiving ORT and in 45 of the 53 calves receiving IF. Thirty-seven of the IF calves were very severely acidotic (TCO_2 < 8 mmol/l) at admission and received an additional 400 mmol bicarbonate added to the first 5 liters of infusion. Treatment was successful in 33 of these calves. The decision to administer additional bicarbonate was based on consideration of acid-base status as measured with a Harleco apparatus.

SID was calculated retrospectively for all calves. While there was a significant correlation between SID and TCO_2 among the ORT group, this was not the case among the control or IF calves. In 13/21 of the calves receiving ORT and in 13/37 of the calves receiving IF, pre-treatment SID values were in the range for healthy calves. Thus the use of SID in these cases would have failed to diagnose, let alone quantify a metabolic acidosis. Six of these IF calves were very severely acidotic (TCO2 < 8 mmol/l) and received additional bicarbonate in their infusion. These findings would suggest that measurement of SID in diarrheic calves gives little indication of severity of metabolic acidosis. This could have had potentially lethal consequences in this study, since the decision to administer additional bicarbonate hinged on assessment of acid base status. Furthermore, measurement of change in SID during therapy gave little indication as to change in actual acid base status as measured by the Harleco, with SID falling during therapy (suggesting a worsening of acid base status) in 16 calves in which acid base status actually improved. There was a significant correlation between change in SID and change in TCO_2 during therapy among the ORT calves but this was not so in the IF calves.

This study demonstrates the inability of measurement of SID to diagnse and quantify metabolic acidosis in the diarrhoeic calf. Reliance on it could have potentially fatal consequences, bearing in mind the necessity of administering bicarbonate to the severely acidotic calf[7,8] and the hazards associated with its use in the non-acidotic patient. It is equally ineffective in assessing changes in acid-base status during therapy which also could have lethal consequences.

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