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Research article

# Hyperchloremic hyperkalemic non-anion gap metabolic acidosis in diarrheic calves treated with 0.9% sodium chloride intravenously

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## Abstract

In this clinical report, we described for the first time a rarely encountered and poorly described acid-base imbalance in diarrheic calves in natural settings. Three, Holstein-Friesian calves aged 9, 17, and 21 days were presented unable to stand after being treated with intravenous 0.9% sodium chloride solution to correct dehydration following an episode of diarrhea for 3 to 4 days. Calves were reportedly recumbent for two days prior to presentation. At presentation, the calves were recumbent but bright and responsive. There was no fever or any signs of dehydration. Serum biochemical analysis revealed hyperchloremia, hyperkalemia and normal anion gap in all 3 calves. A diagnosis of mixed acid-base balance characterized by hyperchloremic hyperkalemic non-anion gap metabolic acidosis was made. The calves recovered after treatment using intravenous injection of 1.3% balanced sodium bicarbonate solution with 5% dextrose for 24 hours. This case report demonstrates the high possibility of diarrheic calves to develop uncommon acid-base imbalances during the course of treatment that may affect negatively the outcome if not treated appropriately.

**Keywords:** Diarrhea, acid-base balance, calves

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## Introduction

Neonatal diarrhea is an important cause of morbidity and mortality in dairy calves (Trefz et al., 2012; Gomez et al., 2013). According to the age of the calf, diarrhea can be a result of bacterial, viral, protozoal or nutritional causes (Lorenz, 2006; Radostits et al., 2007). Dehydration, metabolic acidosis and electrolyte imbalances are serious complications in diarrheic calves regardless of the cause of diarrhea that may play an important role in the outcome of these cases (Omole et al., 2001; Lorenz, 2004; Constable et al., 2005; Gentile et al., 2008; Nakagawa et al., 2008). Metabolic acidosis and electrolyte imbalances such as hyperkalemia may contribute to the depressed condition of the patient and may result in fatal cardiac arrhythmia and renal failure (Lorenz, 2004; Nakagawa et al., 2008). The main causes of the metabolic acidosis in diarrheic calves are fecal bicarbonate loss, electrolyte and fluid loss, and D/L-lactic acidosis (Constable et al., 2005). In this report, we describe 3 cases of neonatal calves with mixed acid-base imbalance characterized by hyperchloremic hyperkalemic metabolic acidosis and high anion gap acidosis that was diagnosed after the calves were treated with intravenous 0.9% sodium chloride solution to correct dehydration following an episode of diarrhea for 3 to 4 days.

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**History and clinical findings**

Three, Holstein-Friesian calves aged 9, 17, and 21 days were presented. The calves were reportedly treated by the farm veterinarian during an episode of diarrhea for 3 to 4 days prior to presentation using 0.9% solution of sodium chloride intravenously. Each calf was given 8 to 10 liters of intravenous fluid per day along with a daily 10% of body weight milk replacer via bottle or stomach tube divided into 2 separate doses. The 3 claves belonged to a dairy herd where newborn calves are housed in a group of house for 24 hours after calving then they are moved to wooden individual boxes. Calves were reportedly given good quality colostrum at 10% of body weight within 4 hours of birth and another feeding 6 hours later.

At presentation, the calves were unable to stand but they appeared bright and alert. There were no clinical signs of dehydration and the calves had strong suckling reflex. The heart rate, respiration rate and rectal temperature were within normal limits and the heart and respiration had normal rhythms. There was no abdominal destination on either side. There was no diarrhea at the time of presentation but previously stored fecal samples from the affected calves revealed *Cryptosporidium parvum* on Ziehl-Neelsen stained slides (Fig. 1). Detailed neurological examination revealed no abnormalities besides generalized weakness involving both fore and hind limbs.

Whole blood samples were collected via jugular venipuncture and sent to the laboratory for hematology and serum biochemistry according to previously published procedures (Thrall et al., 2004). The hematology analyses in the 3 calves revealed normal values (Table 1). In the serum chemistry analyses, there were hyperkalemia and hyperchloremia (Table 2). A venous blood sample was then submitted to the laboratory for blood gas analysis (I-STAT Blood Gas Analyzer, Abbott Point of Care Inc., New Jersey, USA) which revealed acidemia, decreased partial pressure of carbon dioxide ($PaCO_2$), decreased bicarbonate concentrations ($HCO_3^-$), negative base excess, and an increased anion gap in the 3 calves (Table 3).

A diagnosis of hyperchloremic hyperkalemic metabolic acidosis with normal anion gap was made. The 3 calves were treated using 1.3% isotonic solution of sodium bicarbonate supplemented with 5% dextrose intravenously. The 3 calves made full recovery within 24 hours of treatment.

## Discussion

*Cryptosporidium parvum* is a common cause of diarrhea in neonatal dairy calves with poor sanitary conditions worldwide. Clinically, affected calves are anorexic and quickly become dehydrated and depressed leading to coma and death if not treated appropriately (Gentile et al., 2008; Gomez et al., 2013). Untreated calves usually die because of severe hypovolemia leading to cardio-renal collapse, acidosis, electrolytes imbalances and endotoxemia (Lorenz, 2006; Radostitis et al., 2007).

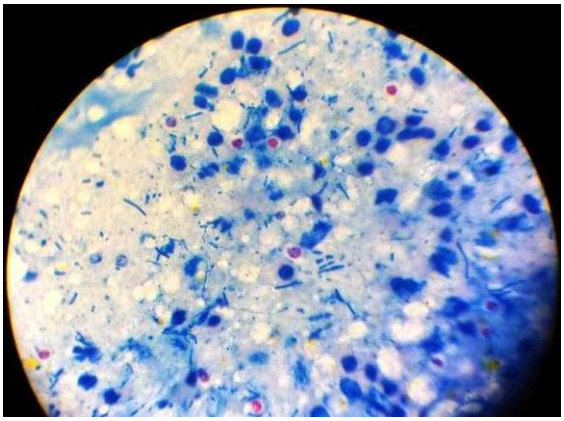

**Fig. 1: Ziehl-Neelsen stained slide of fecal material from a calf with diarrhea caused by *Cryptosporidium parvum*.**

**Table 1: Hematology variables in 3 recumbent calves**

| | WBC ($\times10^3$/µl) | RBC ($\times10^6$/µl) | Hb (g/dl) | HCT (%) | Platelets ($\times10^3$/µl) |
|---|---|---|---|---|---|
| Reference range [4] | 4-12 | 5-10 | 8-15 | 24-46 | 250-450 |
| Calf 1 | 6.8 | 7.3 | 10 | 29 | 360 |
| Calf 2 | 8.5 | 7.5 | 11 | 30 | 318 |
| Calf 3 | 9.5 | 6.5 | 10 | 30 | 283 |

WBC: WHITE BLOOD COUNT; RBC: RED BLOOD CELLS; HB: HEMOGLOBIN

As rough guide to fluid therapy in the field, the degree of dehydration and acidosis in diarrheic calves is commonly assessed based on the age of the calf, clinical signs and changes in behavior (Trefz et al., 2012; Gomez et al., 2013). However, these relationships were recently challenged in an experimental study where the intravenous administration of hydrochloric acid induced severe hyperchloremic metabolic acidosis with no abnormal clinical signs or depression (Lorenz, 2006). On the other hand, changes in demeanor and posture in calves with naturally acquired diarrhea was found to be closely associated with increased serum d-lactate concentrations rather than with decreased base excess (McClure, 2001; Lorenz, 2004; Leal et al., 2012).. Furthermore, it was found that in acidemic calves with or without diarrhea, the primary contributing electrolytes imbalances were hyponatremia accompanied by normochloremia or hyperchloremia, increased d-lactate concentrations, and increased total plasma protein concentrations (Constable et al., 2005).

**Table 2: Serum biochemistry analysis of 3 recumbent calves**

| | Calcium (mg/dl) | Magnesium (mg/dl) | Sodium (mmol/l) | Potassium (mmol/l) | Chloride (mmol/l) | Creatinine (mg/dl) | BUN (mg/dl) | ALT (IU/l) | AST (IU/l) |
|---|---|---|---|---|---|---|---|---|---|
| Reference range [4] | 8.2-10 | 2.0-2.8 | 132–152 | 3.9–5.8 | 95–110 | 0.5-1.1 | 6-22 | 25-74 | 58-100 |
| Calf 1 | 10 | 1.36 | 138 | 6.0 | 113 | 1.2 | 22 | 8 | 12 |
| Calf 2 | 9 | 2.13 | 137 | 6.25 | 112 | 0.9 | 23 | 10 | 8 |
| Calf 3 | 9 | 1.9 | 136 | 6.53 | 110 | 1.1 | 18 | 6 | 11 |

BUN: blood urea nitrogen; ALT: alanine transaminase; AST: aspartate amino transferase.

**Table 3: Blood gas analysis of 3 recumbent calves**

| | PH | PCO2 (mmHg) | $HCO_3^-$ (mmol/l) | Base excess (mmol/l) | Anion gap (mmol/l) |
|---|---|---|---|---|---|
| Reference ranges [2] | 7.35–7.50 | 34–45 | 20-30 | 0 to +5 | 14–20 |
| Calf 1 | 7.01 | 48 | 12 | -20 | 16 |
| Calf 2 | 7.05 | 49 | 13 | -18 | 18 |
| Calf 3 | 7.12 | 50 | 15 | -14 | 17 |

In this report here, we made a diagnosis of a rare metabolic acidosis in naturally occurring diarrhea in calves. This metabolic disorder was characterized by heperchloremia, hyperkalemia and normal anion gap. These calves appeared bright and alert with good appetite and no dehydration. The obvious cause of this condition in these 3 calves was reportedly the intravenous administration of hydrochloric acid solution (0.9%) to treat dehydration. Previous experiments in healthy calves have failed to reproduce the clinical picture observed here in naturally occurring diarrhea by simply administering 0.9% sodium chloride solution intravenously (Gentle et al., 2008). This led us to the conclusion that there must be other factors responsible for general weakness and recumbency in affected calves.

## Conclusion

In conclusion, this case report demonstrates the high possibility of diarrheic calves to develop uncommon electrolytes and acid-base imbalances during the course of treatment that may affect negatively the outcome if not treated appropriately. Practicing veterinarians must be alert of the possibility of the development of this rare acid-base imbalance when using sodium chloride solution to rehydrate sick calves in the field. Therefore, a more proper choice for calf rehydration is an isotonic crystalloid solution such as lactated Ringer's.

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