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An observational study using blood gas analysis to assess neonatal calf diarrhea and subsequent recovery with a European Commission-compliant oral electrolyte solution

Ríona G. Sayers,*[1] Aideen Kennedy,* Lea Krump,† Gearóid P. Sayers,‡ and Emer Kennedy*
*Animal and Grassland Research and Innovation Centre, Teagasc, Moorepark, Fermoy, Co. Cork, Ireland
†Epsilion Ltd., Little Island, Co. Cork, Ireland
‡Department of Science, Technology, Engineering and Mathematics, Institute of Technology Tralee, Tralee, Co. Kerry, Ireland

ABSTRACT

An observational study was conducted on dairy calves (51 healthy, 31 with neonatal diarrhea) during outbreaks of diarrhea on 4 dairy farms. Clinical assessment scores (CAS) were assigned to each healthy and diarrheic calf [from 0 (healthy) to 4 (marked illness)]. Blood gas analysis [pH, base excess (BE), Na^+, K^+, Ca^{2+}, Cl^-, glucose, total hemoglobin, standard HCO_3^-, strong ion difference (SID), and anion gap (AG)] was completed for each calf. Repeated measurements were taken in healthy animals, and pre- and postintervention measurements were taken for diarrheic calves. The mean CAS of diarrheic calves was 1.7, with 51, 30, 17, and 2% of calves scoring 1, 2, 3, and 4, respectively. The mean value for blood pH, BE, AG, and SID was 7.26, −4.93 m*M*, 16.3 m*M*, and 38.59 m*M*, respectively. Calves were administered an oral rehydration and buffering solution (ORBS; Vitalife for Calves, Epsilion Ltd., Cork, Ireland) and reassessed. The mean CAS decreased to 0.38 (65% of calves scored 0 and 35% scored 1) at 6 to 18 h posttreatment and to 0.03 (98% of calves scored 0 and 2% scored 1) within 24 to 48 h. Significant increases in mean value for pH, BE, HCO_3^-, Na^+, and SID, and significant decreases in AG, K^+, Ca^{2+}, and total hemoglobin were recorded posttreatment. The correlation estimates indicated that pH, HCO_3^-, and BE were strongly correlated with CAS, with values exceeding 0.60 in all cases. Administration of an ORBS with a high SID and bicarbonate buffer demonstrated rapid recovery from a diarrheic episode in dairy calves.
Key words: acidosis, blood gas analysis, electrolyte, neonatal calf diarrhea

INTRODUCTION

Neonatal calf diarrhea is the most common cause of mortality in calves (Torsein et al., 2011; Azizzadeh et al., 2012). Electrolyte disturbance, dehydration, and metabolic acidosis, accompanied by a strong ion difference (**SID**), are the most significant consequences of diarrhea in calves (Smith and Berchtold, 2014). Veterinary assessment of calves with diarrhea is generally based on clinical examination alone; however, blood gas analysis remains the most detailed approach to assess the degree of electrolyte disturbance and acidosis in diarrheic calves. Russell and Roussel (2007) have previously highlighted blood gas analysis as a useful tool in practice, especially when combined with history and physical examination.

In many cases, initial diagnosis and treatment of neonatal calf diarrhea is predominantly carried out by primary producers (farmer or manager), who utilize an oral rehydration and buffering solution (**ORBS**) as a first inexpensive attempt to address calf diarrhea. An ORBS is recommended for a diarrheic calf when dehydration is less than 8% and there is still evidence of a suckle reflex (Lorenz et al., 2011). The purpose of the ORBS is to promote plasma expansion, correct electrolyte imbalances, and provide glucose as a co-transport partner of sodium to facilitate water resorption and an alkalizing agent to address the strong ion or metabolic acidosis (Smith, 2009). However, uncertainty remains regarding the optimal electrolyte concentrations, type of buffer, energy source, and osmolality of the ideal ORBS solution (Naylor, 1989; Constable et al., 2009; Sen et al., 2009). Accordingly, a large number of ORBS products are commercially available, differentiated by composition and administration protocols (Smith and Berchtold, 2014). This makes it difficult for producers and veterinarians to identify a product that best suits the needs of diarrheic calves.

European Commission regulation No 5/2014 amending European Directive 2008/38/EC (European Union,

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[1]Corresponding author: Riona.Sayers@teagasc.ie

2014) sets requirements and recommendations for an ORBS to be suitable for treatment of electrolyte imbalance and acidosis in calves. It emphasizes a minimum SID value of 60 m*M* for such therapies. Based on the interpretation of Stewart (1981), SID is regarded as the major factor in determining the alkalinity of an ORBS and as a valid approach when formulating an ORBS for calves with diarrhea and metabolic derangement (Stämpfli et al., 2012). The optimal SID for an ORBS has not been determined, with estimates ranging from 60 m*M* (Smith and Berchtold, 2014) to 110 m*M* (Stämpfli et al., 2012).

The question as to which is more important—an ORBS with high SID or an ORBS with an alkalinizing agent—has yet to be definitively answered (Smith and Berchtold, 2014), and no consensus exists on a suitable alkalinizing agent. The use of bicarbonate precursors such as acetate or propionate are favored over bicarbonate for their energy value once metabolized, their water absorption capabilities, and the fact that they do not alkalinize the abomasum. Bicarbonate was believed to inhibit abomasal milk clotting; however, this has not been supported by recent studies (Bachmann et al., 2009; Constable et al., 2009).

Unlike medicines, which undergo rigorous testing before European Commission (**EC**) approval, ORBS within Europe are not assessed for clinical efficacy before market placement. Although a limited number of studies have assessed various aspects of ORBS treatment in natural neonatal calf diarrhea (Naylor, 1989; Stämpfli et al., 1996, 2012; Constable et al., 2009; Grünberg et al., 2013; Kirchner et al., 2014), there is a lack of observational field studies in recent years examining the efficacy and suitability of ORBS for use in calf diarrhea (Meganck et al., 2014), particularly for data relating to ORBS conforming to recently amended European Union (**EU**) legislation.

In an attempt to increase scientific knowledge in this area, the aim of this observational study was to investigate outbreaks of calf diarrhea on 4 dairy farms using rapid "pen-side" blood gas analysis and subsequently evaluate treatment of diarrheic calves using an ORBS that is compliant with current EU legislation.

MATERIALS AND METHODS

Study Approval

This study was approved by the Teagasc Animal Ethics Committee (TAEC 81/2014); all procedures were authorized and carried out in accordance with the Health Products Regulatory Authority (HPRA) of Ireland (AE19132/P037).

Clinical Assessment Score

To comparatively assess diarrheic calves pre- and posttreatment, a 5-point clinical assessment scoring (**CAS**) chart was used. This chart was developed for use by farm managers and veterinarians at Teagasc (Irish Agriculture and Food Development Authority, Carlow, Ireland) dairy research farms. Clinically healthy calves were assigned a CAS of 0, with varying degrees of ill health scored in increments of 1 to a maximum of 4, as outlined in Supplementary Figure S1 (http://dx.doi.org/10.3168/jds.2015-10600). We constructed the chart based on previously published dehydration charts (Naylor, 1989) and the Wisconsin respiratory calf health-scoring model (http://www.vetmed.wisc.edu/dms/fapm/fapmtools/8calf/calf_health_scoring_chart.pdf; McGuirk, 2008). The chart incorporated calf demeanor, ear position, mobility, suckle reflex, enophthalmos, and desire-to-feed variables. Temperature was not recorded, as the study sought to use variables most indicative of dehydration and metabolic acidosis, and variables that would be routinely observed by producers on commercial farms. Additionally, no attempt was made to identify the underlying cause of the diarrhea, as it was not the focus of the research. Clinical assessment was completed before each blood sample was taken and, in the case of diarrheic calves, an additional assessment was conducted at 24 to 48 h posttreatment. All calves were assessed and scored simultaneously by 2 research veterinarians and a single consensus score was recorded. All CAS were recorded before generation of blood gas results.

Sample Population

An observational study of 77 calves from 2 research (A and B) and 2 commercial (C and D) dairy farms was completed over a 21-d period in spring 2015. A description of husbandry regimens on each study farm for calves in the first month of life is presented in Table 1. Calves were defined as clinically healthy if they recorded a CAS of 0 (as previously described) and had no evidence of diarrhea. Healthy calves were sampled on farm A during a period when no cases of diarrhea had been recorded on the farm from the start of the calving season to the time of assessment (n = 28; 71 measurements). Healthy case animals were also identified on farms B (n = 4; 6 measurements) and C (n = 19; 19 measurements) during a period of diarrhea outbreak on those farms. Diarrheic case calves were defined as having a CAS of 1 or greater, and evidence of diarrhea. Such calves were identified on farms B (n = 9), C (n = 2), and D (n = 12). A diarrhea outbreak subsequently