Research in Veterinary Science 93 (2012) 435–439

Contents lists available at ScienceDirect

Research in Veterinary Science

journal homepage: www.elsevier.com/locate/rvsc

Evaluation of Precision Xceed® meter for on-site monitoring of blood β-hydroxybutyric acid and glucose concentrations in dairy sheep

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ARTICLE INFO

Article history:
Received 14 April 2011
Accepted 22 June 2011

Keywords:
β-Hydroxybutyric acid
Dairy sheep
Glucose
Ketosis
Pregnancy toxemia
Rapid test

ABSTRACT

The accuracy of the Precision Xceed® hand-held meter as an on-site method for measuring blood β-hydroxybutyric acid (BHBA) and glucose concentrations, for the diagnosis of pregnancy toxemia and ketosis in dry and lactating dairy sheep, was assessed. Five to eight hours after the start of the morning feed, blood was collected once from 193 clinically healthy sheep (143 dry and 50 lactating). BHBA and glucose analyses were performed with serum in the laboratory, and with whole blood with the Precision Xceed®. Overall, BHBA and glucose determinations by the two methods were not statistically different ($P > 0.05$). Strongly significant positive correlations were found for glucose and BHBA concentrations between the Precision Xceed® and laboratory results ($r = 0.76$, $n = 150$, $P < 0.01$ and $r = 0.99$, $n = 193$, $P < 0.01$, respectively). The Precision Xceed® was highly sensitive (98.6%) and specific (98.2%), and had excellent test agreement for the detection of pregnancy toxemia and ketosis.

1. Introduction

Early and accurate diagnosis of subclinical metabolic disorders, like pregnancy toxemia and ketosis, is important for the dairy sheep industry. An immediate and accurate diagnosis usually increases the possibility for their successive treatment and prevention (Brozos et al., 2011).

It is accepted that measurement of blood β-hydroxybutyric acid (BHBA) concentration in the laboratory is the gold standard for the diagnosis of ketosis (Oetzel, 2007). Alternatively, the diagnosis can be made by monitoring blood BHBA or urine acetoacetate on-site; however, as it has been proved in cows, their sensitivity and specificity can differ to actual blood concentrations (Oetzel, 2004). Since laboratory measurement of BHBA is costly and time consuming, a reliable on-site test for measurement of blood BHBA and glucose concentrations for diagnosis of pregnancy toxemia or ketosis will be useful in clinical practice or data collection during research.

Abbott Laboratories have developed a small hand-held meter (trade name in Greece: Precision Xceed® and elsewhere: Precision Xtra®) for use in people, which measures whole blood BHBA or glucose concentrations, using appropriate strips. In cows, the meter has been found to be accurate for measurement of blood BHBA concentration (Voyvoda and Erdogan, 2010). There are no reports on the accuracy of this meter in measuring blood BHBA or glucose concentrations in sheep.

Objective of this study was to determine the accuracy of Precision Xceed® hand-held meter for rapid measurement of blood BHBA and glucose concentrations in sheep.

2. Materials and methods

2.1. Animals, samples and techniques used

One hundred and ninety-three (193) clinically healthy, intensively-managed Chios and Chios crossbred dairy sheep (1–5 years old) were selected and blood-sampled. The animals were divided into two groups: dry sheep (10–30 days pre-lambing; $n = 143$) and lactating sheep (5–40 days post-lambing; $n = 50$).

BHBA analyses were performed for all the 193 ewes, whereas glucose was measured for 150 sheep (100 lactating and 50 dry). Two blood samples were collected from the jugular vein of each animal, 5–8 h after start of the morning feeding; one sample was collected into a 3 ml glass tube with K_3-EDTA as anticoagulant (Vacuettte®) for hematocrit (HCT) measurement and another into a 10 ml plain glass tube (BD Vacutainer®) without anticoagulant for serum BHBA and glucose measurement. Whole blood BHBA and glucose were measured on-site by means of the Precision Xceed® (Abbott, Abbott Diabetes Care Ltd., Oxon, UK) hand-held meter. Measurement was carried out within 15 min of sampling,

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doi:10.1016/j.rvsc.2011.06.019

following the manufacturers' instructions and at room temperature between 21 and 23 °C.

Hematocrit was measured by means of the Wintrobe method. BHBA and glucose serum concentrations were also measured in the laboratory, by a spectrophotometric kinetic method (Gau, 1987) or a colorimetric spectrophotometric method (Barham and Trinder, 1972), respectively.

2.2. Data management and analysis

Serum BHBA concentrations measured in the laboratory were regarded as the gold standard. Sheep with serum BHBA concentrations ⩾ 0.8 mMol/L were considered at risk for developing pregnancy toxemia (Russel, 1984; Rook, 2000; Sargison, 2007). A similar threshold for ketosis in lactating sheep is not available in the literature, the value of ⩾0.8 mMol/L was used also for that; in that case, sheep with BHBA concentrations <0.8 mMol/L were considered to be healthy.

For statistical analysis, data were entered onto a computerized database and analyzed with the Statistical Program of Social Sciences (SPSS) software for Windows, Version 17.0. Correlation coefficients (Pearson's Product Moment Correlation Coefficient) were calculated between BHBA serum concentrations measured in the laboratory and those obtained with Precision Xceed® for whole blood. Descriptive statistics were carried out for the variables under study. Sensitivity, specificity, positive and negative predicted values and their binomial 95% confidence interval (CI_{95}) for the hand–held meter at the cut-off point (BHBA concentration ⩾ 0.8 mMol/L) and k-statistics (test agreement between the gold standard and the Precision Xceed® hand-held meter) were also calculated. Sensitivity was calculated as the proportion of sheep with serum BHBA concentrations ⩾ 0.8 mMol/L correctly diagnosed by the Precision Xceed® meter. Specificity was calculated as the proportion of sheep with serum BHBA concentrations <0.8 mMol/L correctly diagnosed by the Precision Xceed® meter. The positive predicted value was calculated as the proportion of animals with positive (i.e., ⩾0.8 mMol/L) Precision Xceed® meter value that were at risk for developing pregnancy toxemia or with subclinical ketosis (as defined by the gold standard). The negative predictive value was calculated as the proportion of animals with negative (i.e., <0.8 mMol/L) Precision Xceed® values that were healthy (as defined by the gold standard). Both blood glucose and BHBA concentrations for dry and lactating sheep were compared using the Student's unpaired t-test and for the two methods (laboratory *versus* hand-held meter) using Student's t-test for paired samples. Significance was set at $P < 0.05$.

3. Results

Means, standard deviations, minimum and maximum values of measured BHBA and glucose concentrations using the two different methods are shown in Tables 1 and 2, respectively.

BHBA overall concentrations varied from 0.1 to 5.4 mMol/L. Ranges of serum BHBA concentrations obtained by the laboratory method was 0.3–5.1 mMol/L for dry sheep and 0.3–2.2 mMol/L for lactating sheep. Ranges of BHBA blood concentrations obtained with the Precision Xceed® were 0.1–5.4 mMol/L for dry sheep and 0.2–2.5 mMol/L for lactating sheep. Overall, mean blood BHBA concentrations obtained with any of the two tests (laboratory or rapid test) were not statistically different between, even when data were stratified according to production status (dry or lactating animal) ($P > 0.05$). BHBA concentrations were significantly higher ($P < 0.05$) in dry than in lactating sheep, and this was consistent to using either test (Table 1). However, when data were stratified according to the BHBA threshold value (⩾0.8 mMom/L/<0.8 mMol/L), results obtained between the two tests were significantly different ($P < 0.05$) for BHBA concentrations <0.8 mMom/L.

Table 1
Descriptive statistics of β-hydroxyboutyric acid (BHBA) concentrations in dry or lactating dairy ewes.

BHBA (mMol/L)	Method used							
	Laboratory				Precision Xceed®			
	n	Mean	SD	Range	*n*	Mean	SD	Range
All sheep	193	1.0	1.1	0.3–5.1	193	0.9	1.1	0.1–5.4
Dry sheep	143	1.2[c]	1.3	0.3–5.1	143	1.1[d]	1.3	0.1–5.4
Lactating sheep	50	0.6[c]	0.4	0.3–2.2	50	0.6[d]	0.5	0.2–2.5
Animals with BHBA concentration <0.8 mMol/L								
Dry sheep	97	0.4[e]	0.1	0.3–5.1	96	0.3[e]	0.1	0.1–5.4
Lactating sheep	41	0.5[f]	0.1	0.3–2.2	41	0.4[f]	0.2	0.2–2.5
Animals with BHBA concentration ⩾0.8 mMol/L								
Dry sheep	46	2.5	1.8	0.8–5.1	47	2.5	1.7	0.7–5.4
Lactating sheep	9	1.3	0.5	0.9–2.2	9	1.44	0.6	0.8–2.5

Mean difference of rows and columns with same letter is statistically significant ($P < 0.05$).

Table 2
Descriptive statistics of glucose concentrations in dry or lactating dairy ewes.

Glucose (mg/dL)	Method used							
	Laboratory				Precision Xceed®			
	n	Mean	SD	Range	*n*	Mean	SD	Range
All sheep	150	64.3	8.8	34–84	193	64.5	11.3	29–95
Dry sheep	100	63.3[a]	8.3	34–82	143	63.1[b]	11.9	29–95
Lactating sheep	50	66.4[a]	8.1	45–84	50	67.2[b]	9.5	47–87
At BHBA concentration <0.8 mMol/L								
Dry sheep	92	64.0	7.6	44–82	90	65.0	10.2	41–95
Lactating sheep	41	68.0	7.3	52–84	41	69.3	8.2	50–87
At BHBA concentration ⩾0.8 mMol/L								
Dry sheep	8	52.9	13.1	34–69	10	45.8	13.2	29–78
Lactating sheep	9	59.2	8.2	45–69	9	57.7	9.8	47–78

Mean difference of rows and columns with same letter is statistically significant ($P < 0.05$).

Glucose concentrations varied from 34 to 84 mg/dL with the laboratory method and from 29 to 95 mg/dL with the Precision Xceed®. Overall, mean glucose concentrations were not statistically different ($P > 0.05$) between the two methods, even when data were stratified according to their production status and BHBA cut off point (⩾0.8 mmom/L). Glucose concentrations were significantly higher ($P < 0.05$) in lactating sheep compared to dry sheep with both the laboratory and Precision Xceed® methods, when data were stratified according to production status (dry and lactating) (Table 2).

Analysis of pooled data revealed strongly significant positive correlations (Figs. 1 and 2) for BHBA and glucose concentrations between the test methods and Precision Xceed®; correlation for BHBA was higher than that for glucose ($r = 0.99$, $n = 193$, $P < 0.01$ and $r = 0.76$, $n = 150$, $P < 0.01$, respectively). Also, a statistically significant ($n = 150$, $P < 0.01$) negative correlation ($r = -0.53$) between BHBA and glucose measured with laboratory reference methods was evident, whereas correlation coefficient between BHBA and glucose measured with the hand-held meter was −0.54 ($n = 150$, $P < 0.001$). Overall, test performance of Precision Xceed® hand-held meter at ⩾0.8 mMol/L was highly sensitive and highly specific relative to serum BHBA (Table 3). From sensitivity of 98.6% and specificity of 98.2%, Precision Xceed® provided <1% and <0.5% false negatives and false positives, respectively, for BHBA testing.

The HCT values of sheep in the study ranged from 26.2 to 42.4% (26.2 to 36.5% in dry sheep, 28.4 to 42.4% in lactating sheep).