Retrospective Study of the Correlation of Serum Potassium Concentrations and the Findings of Heart Auscultation in Calves With Neonatal Diarrhea

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ABSTRACT

A retrospective study was conducted of clinical records of calves with neonatal diarrhea up to the age of 14 days concerning certain aspects of blood potassium concentration and heart rate and rhythm. No correlation could be found between heart rates and serum potassium concentrations. Bradycardia was no indicator of hyperkalemia, nor could hyperkalemia be ruled out in animals with tachycardia. Cardiac arrhythmias were not associated with pronounced kyperkalemia, and did not indicate a poor prognosis. It was concluded that, at least in clinical cases of neonatal calf diarrhea, heart rate and rhythm are subject to complex influences and yield no information on the actual serum potassium concentration in a particular animal.

INTRODUCTION

One of the biochemical alterations frequently found in neonatal diarrheic calves is hyperkalemia. Several authors attribute vital, or rather fatal, importance to this phenomenon (1,4,5,6), as the function of cellular membranes depends upon maintenance of a certain gradient of potassium concentration between intracellular and extracellular space. Lewis and Phillips (5) found that in calves with experimental diarrhea, heart rates decreased by 8 ± 2 beats/min per meq/1 increase in plasma potassium concentration. This finding is in agreement with the observation of bradycardia in experimental potassium intoxication (1). Fisher (3), and Lewis and Phillips (5) detected cardiac arrhythmias mainly in diarrheic calves that had elevated blood levels of potassium, and a generally poor prognosis.

Since serum or plasma potassium concentration is not readily determined in ambulatory large animal practice, the earlier findings (3,5) stimulated a retrospective study on the possibility of drawing conclusions about the status of potassium metabolism of affected calves from the

findings of heart auscultation. An indicator of serum potassium levels is desirable if intravenous fluid therapy is to be initiated, as administration of solutions containing potassium in concentrations above the physiologic range is considered unsafe (9).

An attempt was made to answer the following questions: 1. Do calves with decreased, normal, or increased heart rates differ in their serum potassium concentrations? 2. Do differences in heart rate exist between animals with hyperkalemia as compared to those with normal potassium levels? 3. Do differences in serum potassium concentrations exist between calves with cardiaa arrhythmias as compared to those with regular cardiac rhythms? 4. Must cardiac arrhythmias be considered as an indication of poor prognosis?

MATERIALS AND METHODS

The data evaluated in this study were extracted from the clinical records of 222 diarrheic calves under 14 days of age admitted to the University of Munich II. Medical Animal Clinic in 1978 and 1979. All (288) available pairs of data (heart rate and serum potassium concentration) were included, i.e. more than one pair was included from several animals.

Heart rates and rhythms were determined by auscultation. Blood samples were taken from the jugular vein, in most cases within a short period of time after auscultation. Serum was prepared by centrifuging at 3000 rpm for 10 min. Potassium concentration was assessed by flame photometry (using an EPPENDORF flame photometer). Normal heart rate for calves under 14 days of age was considered to be 90 to 110 beats per minute (7), while 25 mg/dl (6.4 meq/l) was chosen as the upper limit of normal potassium concentration although it is above the usually accepted normal range of about 4 to 6 meq/l (2,8). This was done in order to ensure that calves judged as hyperkalemic did indeed have distinctly elevated serum potassium levels.

RESULTS

For comparison of heart rates with potassium concentrations, the 288 pairs of data were divided into 3 groups based on the heart rates (decreased = < 90 beats/min, normal = 90 - 110 beats/min, increased = > 110 beats/min) (Table 1). Considerable variation in heart rate from normal values occurred; however, there were no significant differences in serum potassium levels between the groups.

Average heart rate of calves with serum potassium concentrations up to 25 mg/dl (6.4 meq/l) was compared to that of animals having serum potassium concentrations of 26 mg/dl or higher. (Only one value below 4 meq/l was recorded, and included in the "normal" group.) Results are shown in Table 2. The average heart rates were not significantly different.

When the data were plotted in the form of a scatter diagram (Figure 1), absence of correlation between serum potassium concentration and heart rate became apparent. Mathematical curve fitting for linear, exponential, and logarithmic functions uniformly yielded correlation coefficients of 0.1 (not significant).

In the period covered by the study, 13 of the diarrheic calves had cardiac arrhythmias detectable by auscultation on days when serum potassium was determined. The average serum potassium level and heart rate in these calves were 24.5 mg/dl (6.3 meq/l) and 105.4 beats/min., respectively. In 147 calves with regular cardiac rhythms the average serum potassium level and heart rate were 24.2 mg/dl (6.2 meq/l) and 106.2 beats/min (on the day of admission to the clinic). The difference in serum potassium concentration is not significant.

Of the 13 calves mentioned above, 11 recovered from diarrhea while only two animals died, one 8 days and the other 17 days after cardiac arrhythmias had been detected.

DISCUSSION

The results of this study suggest that there is no consistent correlation in clinical cases of neonatal calf diarrhea between serum potassium concentration and those parameters of heart auscultation that are most objectively assessable by clinical examination, i.e. heart rate and rhythm. Thus, our data do not confirm the finding of Lewis and Phillips (5). Conceivably, differences may exist between experimental cases of diarrhea, and clinical cases with sometimes obscure histories of duration and treatment by the owner prior to hospitalization. However, it appears more reasonable to view heart rate as a parameter that is affected by a variety of factors (e.g. body temperature, blood pH, circulating blood volume, current status of the vegetative nervous system, relation of various blood electrolyte concentrations), acting synergistically or antagonisticaly, with changing and unpredictable predominance. Hence, determination of heart rate provides no information on the serum potassium level of a diarrheic calf. As to the prognostic information of cardiac arrhythmias, our data do not lend support to an overly pessimistic attitude; by no means can arrhythmias per se be considered as an indication of a poor prognosis.

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TABLE 1. Serum potassium concentrations in diarrheic calves with decreased, normal, or increased heart rates (288 determinations in 222 calves).

Heart rate	No. of determinations	Serum potassium
Decreased		22.8 ± 4.0[a] mg/dl
< 90 beats/min	73	
79 ± 9[a]		5.9 ± 1.0 meq/l
Normal		23.2 ± 5.0 mg/dl
90 - 110 beats/min	94	
100 ± 5		6.0 ± 1.3 meq/l
Increased		23.4 ± 5.0 mg/dl
>110 beats/min	121	
125 ± 12		6.1 ± 1.3 meq/l

[a]Mean ± SD

TABLE 2. Average heart rates of diarrheic calves with normal or increased serum potassium concentrations (288 determinations in 222 calves).

Serum potassium	No. of determinations	Heart rate
Normal	233	104.3 ± 20.4[a]
≤ 25 mg/dl		
Increased	55	109.6 ± 22.5
≥ 26 mg/dl		

[a]Beats/min; Mean ± SD

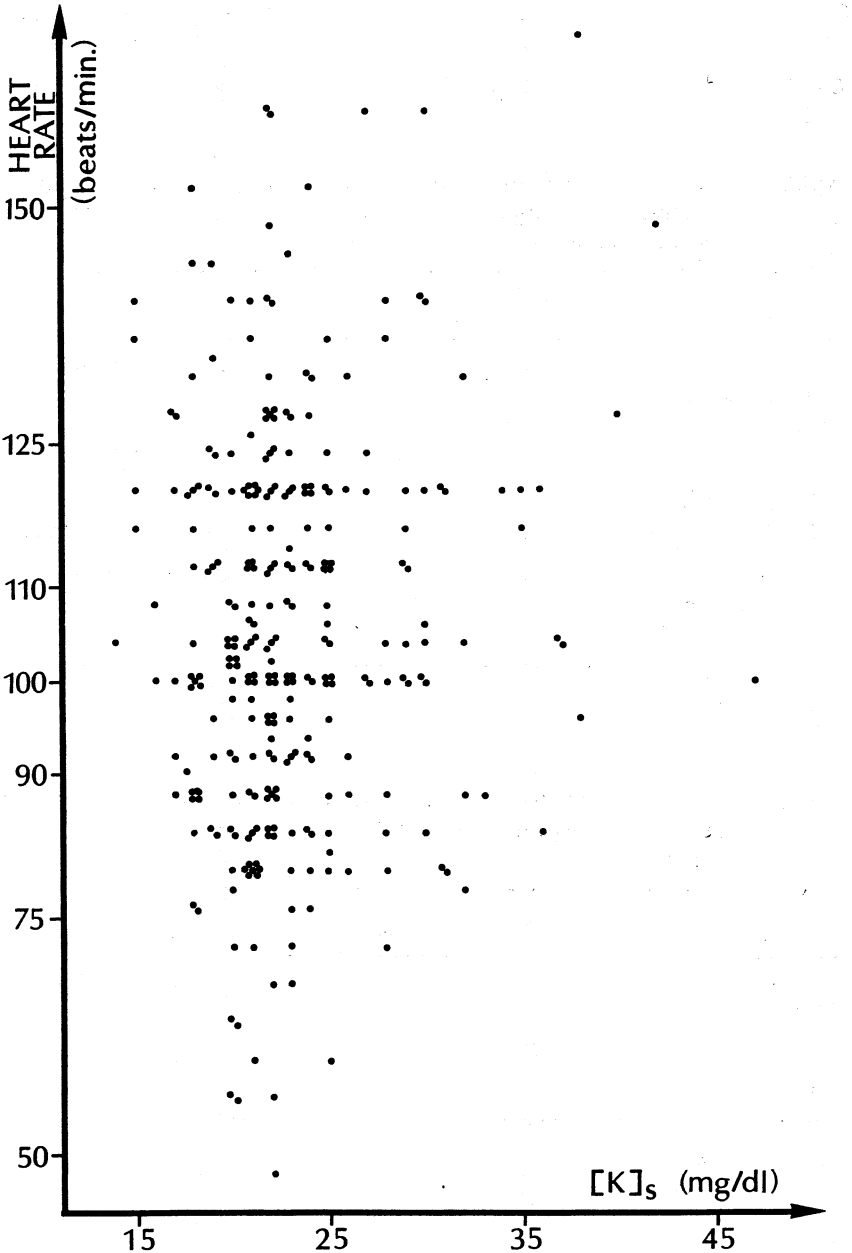

Fig. 1. **Heart rate as a function of serum potassium concentration ($[K]_s$) in calves with neonatal diarrhea.** (288 determinations in 222 calves).

DISCUSSION OF PAPER

Acres. Have you ever had the experience of working on a comatose calf and the first instant you do anything with it, either turn it over or put a needle into the jugular vein, it goes into cardiac arrest and dies very suddenly? Have you seen that syndrome?

Klee. Yes, we have. In these calves I often try to put in an intravenous catheter and quite a few of them die. I think it's a circulatory failure.

Acres. Can you correlate that at all with potassium levels?

Klee. Most of them tend to be hypokalemic but I very rarely see bradycardia in these calves.

Acres. Do you see cardiac arrhythmias?

Klee. Not frequently. Just a few days before I left, I had one calf fitted all the classical signs, it was really in poor shape. It had arrhythmias and it had bradycardia and it had the highest potassium levels that I have ever run across. There are calves that fit into this category but there are so many others that don't, that you can't use it as a test.

Acres. I think one of the things that might be worth looking at in this context is the imbalance between circulating potassium levels and intracellular potassium, this may be more important than just the absolute value of the circulating level of potassium. I realize we can't do intracellular potassium on calves we are trying to save, but it seems to me that the imbalance between the intracellular and the extracellular levels may be more critical than the absolute value.

Klee. I agree, that's what I indicated in the beginning but I was trying to find a practical way of telling the practitioners something, or if you want to try to find out those animals that have a good chance of being hyperkalemic, now this is what you have to do or this is what you have to keep in mind.