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Studies on the Bovine Electrocardiogram. I. Electrocardiographic Changes in Calves on Low Potassium Rations.*

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Four calves were placed on a semipurified ration which analyzed 0.10-0.12% potassium. Four control calves were given the same ration except that potassium was added to bring the level of this constituent to 0.35%. The animals were placed on this ration at 160 days of age. Previous to this they received whole milk and a small amount of hay and grain.

Electrocardiograms were usually taken at monthly intervals, but for some periods more frequently. The electrodes, which were of the German silver plate type, were placed on the upper part of the 2 fore limbs and just above the hock on the left hind leg. The areas on which the electrodes were placed were clipped, cleaned and covered with electrode paste applied with vigorous rubbing.

Serum potassium determinations were made on all calves at 2-week intervals, more often when deemed necessary, by a modification of the titrimetric method of Shohl and Bennett.¹

Plasma calcium, phosphorus, and magnesium determinations were carried out at weekly intervals in order to make certain that the ration was not deficient in these elements.

Blood Changes. Calf C 394. On the 270th day of the experimental period this calf had a serum potassium value of 17.0 mg %. Seventy days later this value had fallen to 10.2 mg % and for a period of about 60 days it remained below 13.5 mg %. On the 350th day of the experiment the potassium in the ration was increased to 0.20% for a period of 130 days after which the potassium was again reduced. During this 130-day period the serum potassium level increased to 18.0 mg %, and it has since varied between 15 and 18 mg % in spite of the reduction of potassium in the ration.

Calf C 395. On the 270th day of the experimental period the serum potassium level of this calf was 21.9 mg %. On the 340th day it had decreased to 11.3 mg % and it remained below 14.0 mg % for a period of about 60 days. The potassium of the ration was then

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¹ Shohl, A. T., and Bennett, H. B., *J. Biol. Chem.*, 1928, **78**, 643.

increased to 0.20%. The serum potassium promptly increased to 19.5 mg % and had reached a level of 22.4 mg % when the animal was slaughtered.

Calf C 409. From a level of 19.5 mg % on the 75th day of the experimental period the serum potassium decreased to 10.7 mg % on the 140th day. A low level was maintained for about 90 days. On the 175th day the potassium of the ration was increased to 0.20% and it was kept at this level for 130 days. During this time the serum potassium values returned to normal and have remained so in spite of the reduction of the potassium in the ration to 0.10% at the end of the 130-day period.

Calf C 410. The changes in this calf closely paralleled those of C 409. The serum potassium value of 17.6 mg % on the 70th day decreased to 13.8 mg % on the 160th day. Low values were maintained for about 60 days. During the 130-day period in which the potassium of the ration was increased to 0.20%, the serum potassium rose to 21.0 mg % and has since remained at or near this level.

The serum potassium values of these 4 calves are shown graphically in Fig. 1.

The serum potassium values for the 4 control calves averaged respectively 21.4 ± 1.2 mg %, 20.4 ± 1.5 mg %, 20.5 ± 1.4 mg % and 21.6 ± 1.8 mg %.

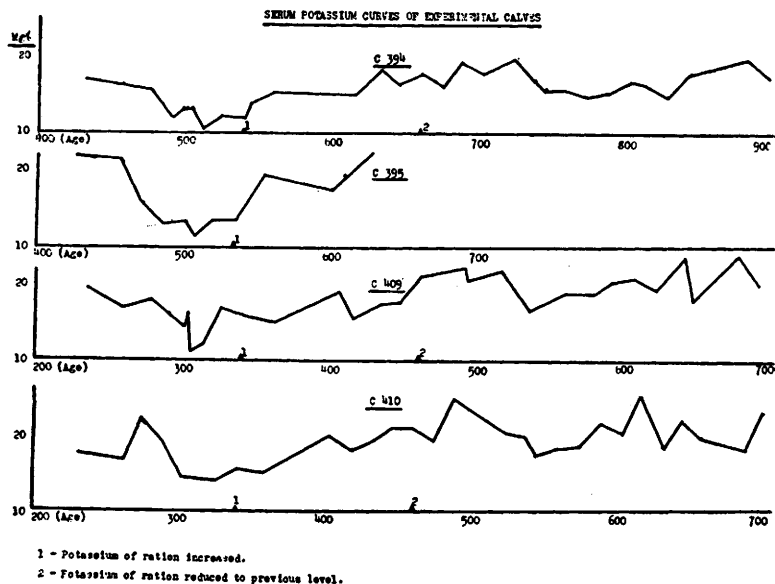


FIG. 1.
Serum potassium curves of the experimental calves.

The calcium, phosphorus and magnesium values of the plasma remained within normal limits in both experimental and control animals.

Electrocardiographic Changes. Three of the 4 experimental animals showed pronounced changes in the electrocardiogram. The other (C 410) failed to show any change, possibly because the serum potassium did not fall so low or remain at as low a level for so long a period in this calf as in the others.

The outstanding change in the electrocardiograms of these calves consisted in a pronounced increase in the duration of the QRS. The Q-T interval, also, increased, but this increase was obviously due mainly to the broadened QRS deflection. The P-R interval was within normal limits at all times. In 2 calves the QRS interval increased to more than 0.16 second and in one calf it exceeded 0.20 second. These QRS intervals are approximately twice as long as those displayed by the electrocardiograms of normal mature cattle and the electrocardiograms of the control animals. In a group of 97 animals, 60 of which were over 2 years of age, the average duration of QRS was .094 second and its maximum duration was 0.12 second (Alfredson, unpublished data). Barnes, Davis, and McKay,² who studied

TABLE I.
Heart Rate and Duration of QRS in Experimental Calves.

C 394			C 395			C 409			C 410		
Age	Rate	QRS	Age	Rate	QRS	Age	Rate	QRS	Age	Rate	QRS
175	43	.10	177	72	.08	26	107	.06	32	120	.06
216	42	.12	210	44	.10	77	75	.06	83	100	.06
253	58	.08	255	42	.08	105	84	.06	111	94	.06
260	65	.09	304	125	.06	176	112	.07	172	94	.06
309	79	.12	305	107	.08	189	88	.07	185	107	.08
330	100	.12	381	100	.10	211	88	.08	207	79	.08
386	79	.10	403	84	.12	224	100	.06	220	88	.08
408	84	.10	416	63	.11	237	88	.08	233	63	.08
421	125	.10	429	50	.12	299	63	.14	272	60	.07
434	52	.10	461	48	.13	300	88	.14	295	43	.08
460	47	.10	482	52	.12	301	92	.12	309	43	.08
484	65	.10	505	50	.16	302	88	.08	359	68	.08
485	65	.08	555	47	.16	306	77	.08	437	72	.08
486	65	.10	633	84	.18	308	79	.10	479	50	.08
490	56	.11				313	42	.09	528	75	.09
492	56	.12				363	72	.12	563	72	.09
497	33	.12				441	57	.12	595	75	.08
545	52	.12				483	64	.19	623	72	.10
623	75	.17				532	79	.14			
665	63	.18				557	68	.16			
714	63	.20				591	70	.15			
749	56	.24				619	60	.18			
773	48	.20									
801	50	.24									

² Barnes, L. K., Davis, G. K., and McKay, C. M., *Cornell Vet.*, 1938, **38**, 16.

TABLE II.
Heart Rate and Duration of QRS in Control Calves.

C 387			C 392			C 419			C 420		
Age	Rate	QRS	Age	Rate	QRS	Age	Rate	QRS	Age	Rate	QRS
217	50	.06	214	72	.08	56	150	.06	67	54	.06
247	94	.06	219	54	.07	69	75	.06	90	58	.07
298	68	.06	250	88	.07	114	55	.07	120	94	.07
340	68	.07	286	91	.08	135	68	.07	154	65	.07
361	57	.08	293	97	.08	174	75	.07	232	68	.07
417	58	.09	300	100	.08	208	120	.08	274	100	.08
439	68	.07	342	75	.08	286	88	.08	323	88	.08
454	75	.08	363	68	.08	318	100	.07	358	88	.08
506	60	.07	398	75	.09	367	115	.08	392	84	.07
529	63	.10	419	68	.08	402	65	.07	420	79	.08
559	54	.08	441	65	.09	436	84	.08	517	72	.08
671	56	.11	467	65	.08	464	88	.08	558	79	.08
713	65	.10	506	68	.09	561	65	.09			
763	57	.12	542	60	.09	602	72	.09			
			569	60	.08						
			604	42	.09						
			682	72	.08						
			724	94	.09						
			773	63	.10						

normal calves ranging from 12-589 days of age, reported QRS intervals similar in length to those observed by Alfredson.

The changes in duration of the QRS complex and the heart rate are shown in Table I. Table II gives similar data for the 4 control calves.

The increase in duration of QRS began in 2 of the calves before the lowest levels of serum potassium were reached. In the third calf the increase began to appear when the lowest blood values were observed. The intervals became progressively greater and did not subsequently decrease even though the serum potassium values returned to approximately normal levels when the potassium content of the ration was raised.

The increase in the duration of the QRS complex was accompanied by equally striking changes in its contour and voltage. These changes are illustrated in Fig. 2, in which the electrocardiograms of calf C 394 are reproduced. The changes which occurred in the other animals were similar in a general way but varied in detail. It will be noted that the changes were progressive, and that the final record⁴ resembles the human and canine curves which depict left bundle-branch block. It has been shown, however,³ that section of the left branch of the His bundle in the calf produces relatively minor changes in the QRS interval and curves here in question cannot, therefore, be

³ Alfredson, B. V., and Sykes, J. F., *PROC. SOC. EXP. BIOL. AND MED.*, 1940, **43**, 580.

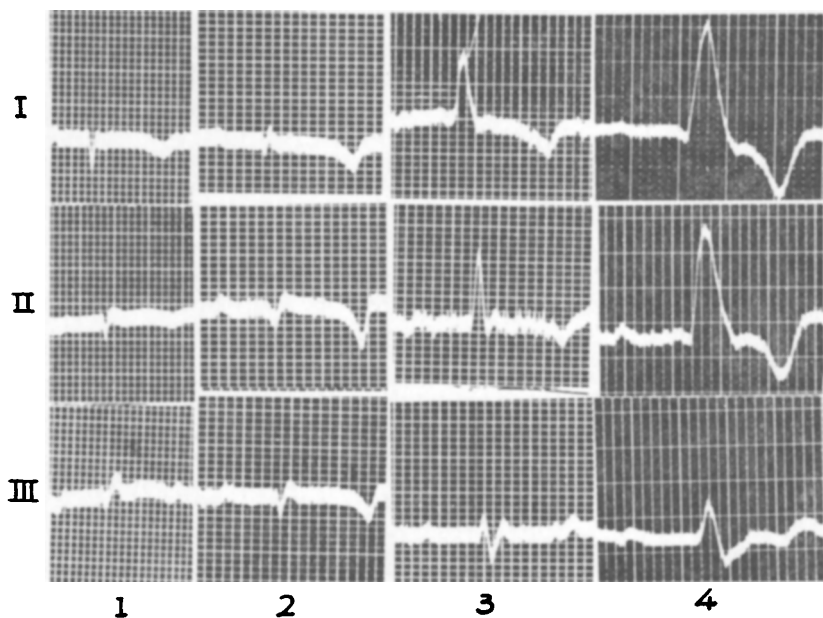


FIG. 2.

Electrocardiogram changes typical of the experimental calves: 1. Control tracing. 2. Tracing at 460 days of age. 3. Electrocardiogram at 492 days. 4. Electrocardiogram taken at 750 days of age.

ascribed to bundle branch block. A preliminary examination of various sections of the Purkinje system of right and left ventricles revealed pathological changes which are not restricted to any one particular region of the heart. A later report will describe these changes in further detail.

Arrhythmias appeared at irregular intervals both during the experimental period and during the preexperimental period. They were perhaps more frequent during the former than during the latter but the difference was not great enough to be of certain significance.

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