The Electrocardiogram of the Normal Dog.* (20561)

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In the course of investigating cardiovascular changes produced by ventricular puncture in unanesthetized laboratory dogs, it became desirable to follow the electrocardiographic patterns over a period of time. For this purpose it was necessary to have a normal range of values against which to compare the variations found in order to determine whether they were significant. It was also essential to know whether the electrocardiograms from a single dog showed changes over a period of time under normal conditions, and if changes occurred the number of readings required on a dog to determine normality would have to be known. Search of the literature revealed no satisfactory criteria.

Smith(1) studied 66 dogs prior to ligation of the coronary arteries. The dogs were anesthetized and in an unstated position. Only standard limb leads were taken. No attempt at detailed analysis was made but it was stated the tracings were "fairly constant in conformation" and in the majority of cases the R wave in lead I was small, the T wave was small in all leads and not infrequently negative. Barnes and Mann(2) studied standard leads of normal unanesthetized dogs in an unstated position prior to coronary artery ligation and reported an extreme variation in T waves. No actual figures were made available. Katz *et al.*(3) studied serial electrocardiograms of standard leads on 3 normal dogs: trained, unanesthetized and on their right side. No data were presented but it was stated the tracings showed irregular fluctuations in form involving changes in amplitude and direction of all complexes, especially the T wave. These variations were neither progressive nor related to environmental factors and were considered normal, due to changes in the position of the heart. Harris and Hussey(4) studied electrocardiograms on 50 dogs in a control study prior to coronary artery ligation. The dogs were anesthetized with intraperitoneal amytal and were in an unstated position. No figures were presented but the authors report an "extreme variability of the so-called normal tracing." Lalick *et al.*(5) reported on 218 standard limb lead tracings on 24 normal trained unanesthetized dogs taken on either right or left side. Five dogs were examined on both sides. No detailed analysis of the tracings was made but it was reported that P waves showed changes in amplitude and direction in the same lead, that T waves were variable in amplitude and direction, and that changes in amplitude or disappearance of Q and S waves occurred. Even though variations occurred in various complexes in different animals the authors believed each dog's records were characteristic for that animal. Finally Petersen and colleagues(6) set up detailed criteria for standard and augmented unipolar limb leads for normal young beagle dogs untrained and unanesthetized in the supine position. Tracings were repeated in the same animal once in 4 instances, twice in 5, and 4 times in one instance. From the repeated tracings it was concluded that the variations in serial electrocardiograms were more marked than in man but not so great as to preclude comparison with one another. Although Petersen's study presented a table of normal values for comparison, the data were accumulated on a single breed and of smaller size than used in our laboratory. No standard deviation was calculated nor was the RS deflection measured nor the P wave except in lead II. The number of tracings on a single dog was insufficient for statistical analysis.

This report concerns the detailed analysis of 62 electrocardiograms on 30 normal laboratory dogs of mongrel breed and indeterminate age. Standard limb leads and augmented unipolar extremity leads are reported. The object of the analysis is to establish a

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TABLE I. Electrocardiographic Standards.*

		Leads†					
		I	II	III	AVR	AVL	AVF
P	Mean	.17	.27	.16	−.20	.02	.19
	S.D.	.07	.09	.11	.09	.10	.11
	—Max	.40	.50	.39	.19	.24	.45
	Min	.05	.03	−.27	−.35	−.16	−.10
	% incidence	100	100	100	100	90	100
Q	Mean	.16	.17	.13	.20	.11	.17
	S.D.	.24	.17	.12	.45	.18	.14
	—Max	1.15	.89	.44	1.89	1.27	.70
	Min	0	0	0	0	0	0
	% incidence	70	97	77	20	43	78
R	Mean	1.05	1.77	1.11	.21	.41	1.35
	S.D.	.58	.48	.48	.24	.40	.50
	—Max	2.22	3.09	2.43	1.28	1.79	2.52
	Min	.20	.30	.14	.02	.02	.10
	% incidence	100	100	100	100	97	100
R′	Mean				.06		
	S.D.				.11		
	—Max	.03	.19	.24	.39	.38	.23
	Min	0	0	0	0	0	0
	% incidence	3	13	10	40	23	13
S	Mean	.09	.09	.23	1.21	.30	.17
	S.D.	.14	.18	.31	1.27	.10	.17
	—Max	.80	.79	1.48	2.34	2.58	.67
	Min	0	0	0	0	0	0
	% incidence	47	60	70	89	67	70
R-S	Mean	1.14	1.92	1.39	1.46	.80	1.54
	S.D.	.56	.59	.45	.68	.66	.51
	—Max	2.62	3.09	2.58	2.85	3.41	2.97
	Min	.27	.30	.33	.20	0	.24
	% incidence	100	100	100	100	97	100
T	Mean	.05	.18	.13	−.11	−.04	.13
	S.D.	.17	.26	.23	.20	.14	.23
	—Max	.63	.74	.81	.26	.36	.74
	Min	−.36	−.27	−.26	−.60	−.40	−.25
	% incidence	100	100	100	100	100	100

	P duration	P-R interval	QRS duration	Q-T interval	Wt	Heart rate
Mean	.07	.12	.06	.21	17.9	121
S.D.	.02	.02	.01	.02	3.7	19
Max	.12	.15	.08	.28	32.7	162
Min	.04	.10	.04	.16	12.8	72

* Data from 30 dogs.
† Amplitudes expressed in millivolts and duration in sec.

normal range of values for the average laboratory dog and to set the number of tracings required on a dog to determine normality.

Method. The animals were trained and unanesthetized. All electrocardiograms were taken in the supine position. A direct writing machine was used. On 3 dogs 10 tracings were taken at different times over a period of 5 months, on one dog 4 tracings, on 2 dogs 2 tracings.

Results. The data for the 30 dogs are presented in Table I. In those instances where more than one tracing per dog was done, an average was taken of all figures for that animal. In Table II are presented the data on one of the 3 dogs on whom 10 tracings were taken. Table III indicates the direction of T wave deflections and the electrocardiographic position of the heart as defined by Wilson *et al.*(7) for the group dogs and on each of the 3 on whom 10 tracings were taken. All animals showed a sinus arrhythmia except

TABLE II. Serial Electrocardiographic Readings.*

		Leads†					
		I	II	III	A^VR	A^VL	A^VF
P	Mean	.19	.36	.21	−.23	.05	.28
	S.D.	.03	.08	.09	.03	.03	.07
	—Max	.24	.50	.39	−.19	.07	.45
	Min	.15	.21	.10	−.28	0	.19
	% incidence	100	100	100	100	90	100
Q	Mean	.32	.15			.54	.04
	S.D.	.38	.15			.40	.07
	—Max	1.15	.51			1.27	.19
	Min	0	0			0	0
	% incidence	90	80	10	10	90	30
R	Mean	.94	1.92	1.36	.25	.66	1.61
	S.D.	.28	.12	.29	.26	.51	.14
	—Max	1.43	2.10	1.75	.89	.90	1.78
	Min	.63	1.73	.85	.07	.44	1.39
	% incidence	100	100	100	100	100	100
R′	Mean						
	S.D.						
	—Max				.15		
	Min				.04		
	% incidence	0	0	0	.50	0	0
S	Mean		.30	.74	1.19		.51
	S.D.		.12	.17	.46		.12
	—Max		.48	.93	1.63		.67
	Min		.13	.36	0		.35
	% incidence	0	100	100	90	0	100
R-S	Mean	.94	2.22	2.09	1.51	.66	2.21
	S.D.	.28	.12	.36	.59	.51	.34
	—Max	1.43	2.35	2.58	2.58	.90	2.97
	Min	.63	2.00	1.31	.22	.44	1.73
	% incidence	100	100	100	100	100	100
T	Mean	−.10	.29	.42	−.08	−.22	.33
	S.D.	.17	.27	.20	.21	.14	.22
	—Max	.23	.60	.81	.26	.05	.74
	Min	−.36	−.25	.19	−.28	−.40	.26
	% incidence	100	100	100	100	100	100

	P duration	P-R interval	QRS duration	Q-T interval	Wt	Heart rate
Mean	.06	.13	.05	.19	18.1	120
S.D.	.01	.01	.01	.01		17
Max	.08	.14	.06	.20		151
Min	.04	.11	.04	.18		104

* Ten consecutive readings on one dog.
† Amplitudes expressed in millivolts and duration in sec.

for one who demonstrated normal sinus rhythm. One of the dogs on whom 10 tracings were taken had occasional ventricular premature contractions on one electrocardiogram and occasional auricular premature contractions on another. The S-T segment was isoelectric in every instance.

Smith(1) noted that when the T wave was inverted in all leads (standard limb) the mortality "seemed to be high" within 24 hours after operation for ligation of the coronary arteries. In our series 3 dogs had inverted T waves in all standard leads. One of these 3 had an upright T in ${}_AV_R$ and inverted in ${}_AV_L$ and ${}_AV_F$; one had upright T in ${}_AV_R$ and ${}_AV_L$ and inverted in ${}_AV_F$; the third had diphasic T in ${}_AV_R$ upright in ${}_AV_L$ and inverted in ${}_AV_F$.

Lalick(5) observed that in 78% of records which demonstrated a Q wave in lead I an inverted T_I was present. In our series there were 22 tracings which showed a Q_I of 1 mm

TABLE III. Direction of T-Wave Deflections (in %).

		I	II	III	AVR	AVL	AVF	Heart positions,* %
Group control dogs	Upright	60	70	70	23	33	70	S.H. 33
	Inverted	3	27	30	66	63	23	I. 3
	Diphasic	37	3	0	10	3	7	S.V. 63
Ginger	Upright	10	100	100	10	10	80	S.H. 90
	Inverted	70	0	0	70	90	0	I. 10
	Diphasic	20	0	0	20	0	20	S.V. 0
Lucky	Upright	100	90	40	0	80	60	S.H. 10
	Inverted	0	0	0	90	0	0	I. 10
	Diphasic	0	10	60	10	20	40	S.V. 80
Sandy	Upright	60	80	100	0	10	90	S.H. 90
	Inverted	30	0	0	80	0	0	I. 10
	Diphasic	10	20	0	20	90	10	S.V. 0

* S.H. = semi-horizontal; I. = intermediate; S.V. = semi-vertical.

or larger. In 18 of these or 82% an inverted T_I was present also. Lalick also reported that when Q_I was greater than 4 mm, over 90% was followed by an inverted T. In our 62 tracings 8 demonstrated a Q_I greater than 4 mm and each was followed by an inverted T except one, which showed a diphasic T with the inverted component first 1.8 mm deep and the upright component 0.5 mm high. In Lalick's tracings where an S wave was present in lead III it was followed by an upright T 75% of the time. In our series there were 37 instances of an S_{III} of 1 mm or greater, 31 of these or 84% were followed by an upright T.

Comment. The best procedure to obtain a normal range is to take several readings on many dogs. In our series only single readings were taken on most dogs. Additional readings would have made the frequency distribution more smooth, but probably would not have altered the normal range limits to any extent. From a statistical standpoint the data obtained are satisfactory to establish a normal range. Although the values are not normally distributed the normal range seems to be adequately described for P, R, and T readings by taking the mean plus and minus 2.5 standard deviations; this will leave 1% of the normal values which will fall out of this range. Depending upon the desired conservatism other numbers of standard deviations might be used. For Q and S magnitude where zero values are frequent the range is better described by taking zero plus a number of standard deviations. For example, to establish a range including 99% of the normal values, instead of taking the mean plus and minus 2.5 standard deviations, the range would be 0 plus 5.4 standard deviations. Variations in tracings on the same dog taken at different times are as great as among different dogs. The results of analysis of the variance test applied to 10 successive readings on each of 3 dogs for the value of P_I reveals no significant difference between the variation found in the same dog and that found among the 3 dogs. Because of the variation found within the same animal it is preferable to use the mean of 3 tracings in order to reduce the effect of the occasional extreme value.

Summary. 1. A table of values is presented for the electrocardiogram of the average normal laboratory dog; trained, unanesthetized, and in the supine position, based on data from 62 tracings on 30 dogs. 2. Data obtained from 10 serial tracings on each of 3 dogs indicates a variation within the same animal not significantly different from that obtaining among different animals. 3. It is recommended that to establish the normal electrocardiogram of a dog a mean of 3 tracings taken at different times be used to reduce the effect of the occasional extreme value.

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Peripheral Blood Concentrations of Steroids in Man After Oral Administration of 17-Hydroxycorticosterone.* (20562)

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Recent developments in chromatographic and micro-analytical technics for the resolution and quantitation of steroids make possible the analysis of corticosteroids in peripheral blood of man. A method for analyzing 17-hydrocorticosteroids in peripheral blood has been developed by Nelson and Samuels(1). They have employed Florosil for resolution and a modified phenylhydrazine reaction(2) for quantitation of the steroids. The method of Sweat(3) utilizes silica gel for resolution and sulfuric acid fluorescence for quantitation of corticosterone-like steroids and 17-hydroxycorticosterone. In the present study the technic of Sweat has been applied to the determination of the concentrations of steroids in peripheral blood of man following the oral administration of a single dose of 17-hydroxycorticosterone.

Methods. Eight normal adult males were subjects for this study. Immediately following withdrawal of a control blood sample, 6 of the subjects received 50 mg of 17-hydroxycorticosterone (Hydrocortisone, Merck) orally; blood samples were collected at various time intervals thereafter for steroid analysis. In control subjects, blood samples were collected and analyzed, but no hormone was given. Twenty ml of blood were drawn from an antecubital vein, mixed with ⅓ ml of heparin and centrifuged. Ten ml of separated plasma were analyzed for steroid content. The method employed for analysis of corticosterone-like steroids and 17-hydroxycorticosterone in plasma was that developed by Sweat. In brief, this method consists of a) extraction of the plasma sample with 10 volumes of chloroform, b) fractionation of the dried chloroform extract between 70% ethanol and petroleum ether and c) resolution on a silica-gel column by elution with mixtures of ethanol and chloroform in various ratios. The resolved steroids were quantitated by the degree of fluorescence developed in concentrated sulfuric acid. Recovery studies have shown that approximately 95% of 17-hydroxycorticosterone and 80% of corticosterone added to plasma are resolved and recovered by this technic.

Results. The individual values obtained for the concentration of 17-hydroxycorticosterone are plotted in Fig. 1. Curve A is a line of best fit based on results obtained in 5 individuals who received 50 mg of 17-hydroxycorticosterone orally. A significant increase in plasma concentration of the hormone occurred 15 minutes following its administration. The peak concentration was attained between 45 and 60 minutes; normal values were reached between 4 and 6 hours. Curve

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