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PREFACE

Adrenaline or epinephrine, the active principle of the medullary portion of the suprarenal gland, is well known to have a very pronounced effect on many animals when injected into the blood stream. The physiological reaction to this hormone is, in almost all organs, the same as the response to stimulation by the sympathetic nerves: there is a vasoconstriction of the arterioles producing a rise in blood pressure; peristalsis is inhibited; unstriped muscle fibers are contracted or relaxed depending upon the function of the sympathetic nerves on the muscle.

Accompanying this neurological effect of adrenaline, there is an equally striking modification of the carbohydrate metabolism producing a rapid and marked rise in blood glucose, an increase in blood lactic acid, and an initial rise in the respiratory quotient. It has been further reported that there is a concomitant decrease in blood chlorides and inorganic phosphates following adrenaline administration. These observations are not confirmed by all workers, however. This study is concerned with the effect of adrenaline injections upon the blood chlorides and chloride distribution and the inorganic phosphates and phosphorus distribution of the blood of rabbits, rats, and chickens.

INTRODUCTION

An investigation of the literature indicates that there is lack of agreement among various workers in the field as to the effect of adrenaline injections on the blood chlorides. Thus, Tamura (25) reports that in rabbits adrenaline decreases and insulin increases the Cl content of the blood. Akiya and others (1) confirm this by reporting that adrenaline causes a decrease in Cl, Ca, and inorganic P and the CO_2 tension of the venous plasma and a rise in the pH of normal human blood. Several workers (14, 15) state that there is a reciprocal relation between the blood glucose and chlorides in hyperglucemia produced by injection or ingestion of glucose. Contrary to this are the findings of Urechia and Retezeanu (27), Chaidelis (5), and Flock and others (9), who report that adrenaline injections cause no significant variations in the blood chlorides even though the glucose increases as much as 150%. Cuatricasas and Bruno (8), working with normal adults, find that the plasma chlorides decrease very slightly, that the globular chlorides show small changes in either direction, and that the quotient is scarcely changed within one hour after glucose injections.

Most workers who have investigated the effect of adrenaline on the phosphorus content of the blood state that there is a marked and rapid fall in the inorganic portion. Thus, Bollinger and Hartman (4) record a decrease from 5.5 mg. to 1.0 mg. of phosphorus per 100 ml. of blood in 90 minutes after injection of 5 ml. adrenaline into normal dogs. A reduction in inorganic phosphorus is likewise reported by Vollmer (29), Perlzweig, Latham, and Keefer (20) in humans, Akiya and others (1) in humans, Woringer (32), Barrenscheer, Eisler, and Popper (2). Several workers do not consistently find this decrease, however. In an average of seven rabbits Yamada (33) finds

a decrease of only 0.08 mg. P per 100 ml. of blood, and in several cases the inorganic phosphorus is actually increased. Yamada also reports that there is a decrease in the total phosphorus after adrenaline, phlorhizin, or glucose have been injected. He states that this is in accord with the findings of Nakamura (19). An increase in the inorganic phosphorus in healthy humans of 0.6 mg. to 1.2 mg. P per 100 ml of blood after adrenaline injection is found by Seidel (21); Yamada (33) says that Matsuoka (18) observes a similar change. Ichijo (13) likewise concludes that adrenaline usually increases the blood sugar and inorganic phosphorus content of the blood of normal and hypophysectomized dogs.

In view of the discordant results thus reported, the object of this study was to investigate the effect of adrenaline injections on the total chlorides and chloride distribution and the inorganic phosphate and phosphorus distribution of the blood in enough animals to make relatively certain that any observed changes were not due to individual variation.

Experimental

The adrenaline used in the study was a 1:1000 solution of adrenaline chloride manufactured by Parke, Davis and Company and having the following composition as reported by the company:

Per fluid ounce:

Adrenaline (Epinephrine)	9/20 Grain
Chloretone	2 1/4 "
Physiological NaCl Solution	q.s.
Sodium Bisulphite (not more than)	0.1%

It was obtained fresh at frequent intervals and was discarded at the first indication of oxidation - - a faint pink tinge.

The experimental animals used were selected at random from the reserve cages of the laboratory and were all young and apparently healthy adults. The rats were albinos and usually weighed between 300 and 400 grams; males were used almost exclusively. The rabbits were New Zealand White adults and weighed between 2,500 and 3,000 grams. The chickens were young cockerels and non-laying hens obtained from the college flocks and weighed between 1,000 and 2,000 grams.

The rations of the animals were well balanced, standard type diets commonly given experimental animals. The chickens received the regular growing ration recommended by the Experiment Station.

After the customary inanition period, usually about 18 hours, the animals were selected at random from the group, divided into two comparable lots, and one lot injected subcutaneously with a measured amount of the adrenaline solution. The time of injection was noted. A series of preliminary observations indicated that in the animals used the peak of the sugar curve occurred from 60 to 90 minutes after injection. Consequently, the blood was usually drawn during this interval. In every instance, the control lot was treated under as nearly the same conditions as possible.

The blood was drawn by means of heart puncture with a hypodermic needle

and discharged into 50 ml. Erlenmeyer flasks containing approximately 3.4 mg. of $(NH_4)_2C_2O_4.H_2O$ for each ml. of blood which was expected to be collected; the contents of the flasks were swirled from time to time to prevent coagulation. For each control or experimental group the blood was pooled and the analysis made of an aliquot of the pool by methods which will be described. In order to avoid, if possible, errors introduced by partial coagulation and haemolysis all dilutions and measurements for hematocrits were made as soon after bleeding as possible.

Methods

Hematocrits: Hematocrit readings were obtained by placing the oxalated blood in specially constructed tubes having a bore of 75 mm., approximately 13 cm. in length, and graduated to contain 5 ml.. The tubes were centrifuged for 30 minutes at 3225 r.p.m., removed, and the cell and plasma volume read with vernier calipers.

Blood Glucose: The total sugar in the whole blood was determined in the Folin and Wu (10) filtrate by the colorimetric method of Benedict (3). This method was selected because of its rapidity, adaptability to a small number of samples, and accuracy. When used directly on the blood filtrates as prepared for the determination, it gives results which are closer to the true glucose values than those obtained by older colorimetric techniques. The new copper reagent, when used with bisulphite, is practically unaffected by the non-sugar reducing material present.

Chlorides: There are available for the determination of chlorides in blood a wide variety of methods. Most of the common procedures may be classified on the basis of the method used to remove the protein material present. In one group of procedures the protein is oxidized and the chloride precipitated by heating the blood or tissue with nitric acid and silver nitrate. The

method of Van Slyke (28) is in common use and employes the addition of $KMnO_4$ to hasten the oxidation. The objections to this method are that the time involved in the digestion is considerable (usually from eight to ten hours) and there is some possibility of slight loss of chlorides on long heating. Furthermore, Wilson and Ball (31) report that in certain instances the Van Slyke procedure gives lower results than are found with other methods. The other type of procedure involves the removal of the proteins by precipitation with various reagents. Of the several methods available for the precipitation of blood proteins the ones most commonly used when chlorides are to be determined on the filtrate are the zinc salt precipitation techniques of Somogyi (24), the trichloroacetic acid procedure as described by Smith (23), or the Folin-Wu tungstic acid technique previously described. Greenwald and Gross (11) have compared these and various other protein precipitation techniques and find that values for chlorides by a Vohlard titration following the Folin-Wu tungstic acid precipitation compare favorably with the digestion procedures of Van Slyke. They state in this regard,

> "Apparently the Folin-Wu reagent is, of all those studied, the most suitable for the subsequent determination of chlorides, and, unless there is some difficulty with the subsequent titration, which appears not to be the case, the method described by Whitehorn (30) would seem the most desirable for routine determinations."

In view of the fact that the determination of chlorides in the Folin-Wu filtrate gives results which are quite comparable with those obtained by the method of Van Slyke, and, further, since such a procedure would use the filtrate which would be prepared in any case for the determination of sugar, it was decided to make the determination in this manner. The factor of time was also considered, and, from this point of view, the procedure adopted is superior since no digestion is required.

Two methods are in general use for the determination of chlorides in the protein-free filtrates. The procedure described by Whitehorn (30) applies the Volhard titration using standard thiocyanate to titrate an excess

of silver, using ferric ammonium sulphate as an indicator. This method is widely used, but personal experience indicates that it is difficult to duplicate the end-point in every instance. In titrating to a fading end-point there is considerable opportunity for individual variations, and variations from one run to the next. The other method in use is the McLean and Van Slyke (17) iodometric titration. It has been further modified by Short and Gellis (22) to apply to the Folin-Wu filtrate, and their method was used in this study. It involves the titration of an excess of silver with potassium iodide in a solution containing a sodium citrate-starch buffer. Sodium nitrite and nitric acid are also present and the nitrous acid thus produced oxidizes the iodide to free iodine as soon as all silver has been precipitated as silver iodide. The iodine produces with the starch the characteristic blue end-point which is both sharp and permanent. If the conditions, especially the pH, are carefully controlled, the distinctness of the end-point leaves little to be desired.

For the total chlorides in the whole blood the Folin-Wu filtrate was prepared as described above. In the chloride partition precautions were taken to minimize as far as possible the error introduced by the shift in the chlorides as CO_2 diffused from the erythrocytes. The blood was drawn and oxalated as rapidly as possible and when it was ready for centrifugation a few drops of oil were added to form a film over the surface. This does not prevent the diffusion of CO_2, but does retard it considerably. In this way it was hoped that the erythrocyte-plasma shift might be minimized. Moreover, this error would not be of tremendous significance, if it did occur, since it could be assumed, with justification, that the amount of diffusion from the control and the experimental samples would be nearly equal. Thus any significant change in the concentration due to the adrenaline might still be noted.

In preparing the protein-free filtrate of the plasma the following modification of the Folin-Wu procedure recommended and used by Trimble and Maddock (26) was adopted. One volume of plasma was pipetted with a blood pipette into eight volumes of water and the pipette washed by drawing the mixture into the pipette several times. One-half volume of 10% sodium tungstate was next added, and followed by 1/2 volume of 2/3 N H_2SO_4, drop by drop, with agitation. No difficulty was encountered in obtaining a good removal of protein. For the determination on the cells, one volume of cells, measured in a blood pipette held against a strong light source, were laked with five volumes of water, and the protein precipitated by the addition of two volumes of 10% sodium tungstate and 2/3 N H_2SO_4. The determination of chloride was then made on the various filtrates as directed by Short and Gellis (22).

Phosphorus: The method used for the partition of the phosphorus is an adaptation to the photelometer of the colorimetric method of Youngburg and Youngburg (34) as modified by McCay (16). Further modifications have been made by workers in this laboratory. This method of partition divides the phosphorus into the following fractions: total phosphorus in the whole blood, plasma, and cells; lipoid phosphorus in the plasma and cells; and inorganic phosphorus in the plasma and cells. The lipoid phosphorus is an alcohol-ether mixture extract and consists mainly of phospholipoids; the inorganic fraction is that portion soluble in the trichloroacetic acid filtrate which is determinable directly without further treatment. Since the determination requires the phosphorus be present in the form of orthophosphates, the total and organic phosphorus fractions must be digested by charring with H_2SO_4 and completing the oxidation of any organic material with perchloric acid. The analysis is completed by comparing the depth of color produced by adding molybdic acid reagent and dilute $SnCl_2$ solution, determined in a Cenco-Sheard-Sanford photelometer against standard curves

previously prepared.

This method has been described with some detail by two other workers in this laboratory (12, 35); hence, only the modifications of the original technique as described by them will be mentioned.

The following changes in the preparation of the dilutions for preparing aliquots were necessary because of the smaller quantities of blood available for work. The following dilutions are those for chicken blood; in the blood of animals with a lower concentration of phosphorus it is necessary either to increase the amount of plasma or cells used in the dilution or to take a larger volume of the diluted material for digestion. A good rule is to adjust the dilution so that the color produced in an aliquot falls between 15 and 35 on the photelometer scale.

The separation of plasma and cells was made as follows: After the separation of cells and plasma as described previously, the plasma is drained from the cells and the mouth of the tube wiped to remove any plasma adhering to the sides. If a good separation is not obtained, the tube may be replaced and centrifuged for an additional 15 minutes and the separation completed. Then 0.85% NaCl is added to the cells in the tube to the 5 ml. mark, mixed by rotating and inverting, and drained into a beaker. Next, 5 ml. of 0.85% NaCl is added to the tube and drained into the beaker. The suspension is thoroughly mixed by pouring back and forth from tube to beaker; this suspension is used in making the aliquots for the determinations on the cells.

The following dilutions were made for the various determinations:

Total phosphorus in the whole blood: 0.2 ml. of whole blood is pipetted into 10 ml. of 0.85% NaCl; 1 ml. of the mixture is taken for digestion and determination of phosphorus.

Total phosphorus in the plasma: 0.2 ml. of plasma is pipetted into 3 ml. of 0.85% NaCl; 1 ml. of the mixture is taken for digestion.

Total phosphorus in the cells: 0.2 ml. of cell suspension is pipetted into 5 ml. of 85% NaCl; 1 ml. of the mixture is taken for digestion.

Lipoid Phosphorus in the plasma: 0.5 ml. of plasma is pipetted into a test tube graduated to contain 10 ml. and containing 9 ml. of alcohol-ether solution. The mixture is shaken violently, heated to boiling in a hot water bath, cooled, and made up to 10 ml. with alcohol-ether. The tube is tightly stoppered, centrifuged at 2000 r.p.m. for a few minutes, and 4 ml. of the supernatant liquid pipetted into a tube for digestion.

Lipoid phosphorus in the cells: 1.0 ml. of cell suspension is pipetted into a test tube graduated to contain 10 ml. and containing 9 ml. of alcohol-ether and treated as described above for plasma; 4 ml. of the supernatant liquid is taken for digestion.

Inorganic phosphorus in the plasma: 1 ml. of plasma is pipetted into 4 ml. of 10% trichloroacetic acid, thoroughly mixed by rotating the tube, and centrifuged at 1750 r.p.m. for several minutes; 2 ml. of the supernatant liquid are pipetted into a test tube. Since the phosphorus is already in the form of phosphate ions, no digestion is necessary, and the color is developed in this tube.

Inorganic phosphorus in the cells: 3 ml. of cell suspension are pipetted into 2 ml. of 20% trichloroacetic acid and treated as described for plasma; 2 ml. are taken for determination of the phosphorus.

The digestion of the aliquots was done as described with the modification that the preliminary charring of the organic material was done by allowing the tubes to stand in a drying oven at 110° C. for 24 hours or more.

The development of the color in the digested aliquots was made by adding 7.92 ml. of distilled water, 1 ml. of molybdate reagent B, and 1 ml. of dilute $SnCl_2$ solution. The $SnCl_2$ was added rapidly from a free-flowing

pipette and the color developed was read in the photelometer approximately (as nearly as possible) five minutes after the addition was made. In the inorganic samples, 6 ml. of water, 1 ml. of molybdate reagent A, and 1 ml. of dilute $SnCl_2$ were added and the color developed and read as before. This varies from the original procedure in that the final H_2SO_4 concentration is reduced in the digested samples from 1.0 to .75 N and in the inorganic samples from 1.0 N to .5 N; the concentration of the molybdic acid has likewise been reduced by half. This change produces a more stable, deeper color with less tendency for "off-shades" of yellow and green.

Data

The data were collected, as has been previously described, by the method of "independent series". Since it was considered more desirable to study the effect of adrenaline injections on more than one species of animals, not sufficient data were collected to warrant statistical treatment. However, in several series of determinations the average of the series indicates the general trend of the changes taking place. In preparing the mean values, each experiment was treated as a unit and given equal weight.

TABLE NO. I. Glucose and Chloride Content of the Blood of Rats, Rabbits, and Chickens Following Adrenaline Injections. All Results in Mg. Glucose and NaCl per 100 Ml. of Blood, Plasma or Cells.

Animal	Control Animals					Experimental Animals after Adrenaline Injections						
	No. of Animals	Glucose	Total Cl	Plasma Cl	Cell Cl	No. of Animals	Mg. Adren. Kg. Body Wt.	Min. After Injection	Glucose	Total Cl	Plasma Cl	Cell Cl
Rat	2	111.5	538.5			2	0.4	120	159.1	558.0		
	5	111.5	511.5			3	0.6	120	244.6	508.3		
						3	0.6	260	143.9	513.5		
						4	0.6	380	109.1	506.9		
	4	93.8	511.2			3	0.6	120	337.6	524.3		
	4	101.9	544.8			4	0.6	120	113.8	523.0		
	7	97.8	509.2			6	0.8	60	357.0	503.9		
	6	104.3	531.8			6	0.8	60	335.0	513.5		
	8	106.2	491.8	573.5	395.5	10	1.0	60	330.5	518.3	574.5	424.0
	Ave.	103.86	519.8						240.1	520.35		
Chicken	2	234.5	598.9	679.7	408.2	2	0.8	65	325.5	596.5	683.6	400.5
	2	199.4	584.3	676.8	434.4	2	1.0	70	300.0	614.3	676.4	400.8
	2	255.0	615.8	695.3	452.0	2	1.0	90	331.1	631.2	665.3	454.4
	2	187.2	608.0	674.9	410.8	2	1.0	90	253.0	598.0	671.7	404.3
	2	239.0	600.6	670.8	411.8	2	1.0	60	283.0	572.2	671.9	416.5
	4	157.0	622.9	693.9	467.2	4	1.0	45	198.0	678.9	680.4	474.0
	Ave.	212.0	605.1	681.9	430.7	4	1.0	90	237.0	657.4	690.4	478.0
									275.4	613.4	675.7	435.4
Rabbit	1	100.3	577.8	667.4	390.5	1	0.5	120	423.5	536.2	607.7	425.5
	1	105.0	544.2	637.6	352.9	1	0.5	120	327.0	545.9	683.9	437.7
Dog*	1	121.3	525.5			1	0.2	60	167.0	524.9		

* Same animal control and experimental.

TABLE NO. II. Glucose Content and Phosphorus Distribution of the Blood of Rats, Rabbits, and Chickens Following Adrenaline Administration. All Results in Mg. Glucose and Phosphorus per 100 Ml. of Blood, Plasma, or Cells.

Animal	Exp. No.	Mg. Adren. / Kg. Body Wt.	Min. After Injection Blood Drawn	No. of Animals: Control	No. of Animals: Exper.	Hematocrit percent of cells: Control	Hematocrit percent of cells: Exper.	Glucose: Control	Glucose: Exper.
Chicken	1	2.0	60	2	2	38.6	34.4	258.5	392.0
	2	2.0	110	4	4	37.8	41.9	169.5	283.0
	3	1.0	45	4	4	34.8	38.5	157.0	198.0
	3a	1.0	90		4		36.1		237.0
Ave.						37.1	37.7	194.8	302.5
Rat	4	1.0	75	6	5	52.7	53.6	110.5	369.5
	5	1.0	60	6	7	52.7	56.7	106.4	344.0
	5a			6		51.5		111.3	
	6	1.0	90	5	5	47.55	49.6	85.0	296.0
	7	1.0	60	5	6	54.1	54.5	87.0	292.0
	8	1.0	60	6	6	52.2	50.1	101.2	306.0
	9	1.0	60	5	5	45.25	48.1	96.0	278.0
Ave.						50.85	52.11	98.5	314.25
Rabbit	10	1.0	90	1	1	41.2	41.9	125.75	290.0
	10a			1		29.2		108.3	
	11	0.5	65	1	1	42.9	49.2	105.75	425.5
	12	0.5	70	1	1	49.7	40.1	87.0	292.0
	13	0.5	90	1	1	46.8	43.7	100.75	227.0
	14	0.5	90	1	1	50.1	37.7	88.5	320.0
	15	1.0	60	1	1	46.35	37.65	100.25	387.0
Ave.						48.24	39.71	101.2	323.8

TABLE NO. II-A

Ex. No.	Total P Whole Blood		Total P Plasma		Total P Cells		Lipoid P Plasma		Lipoid P Cells		Inorg. P Plasma		Inorg. P Cells	
	Cont.	Exper.	Cont.	Exper.	Cont.	Exper.	Cont.	Exper.	Cont.	Exper.	Cont.	Exper.	Cont.	Exper.
1											7.38	2.70	3.82	4.37
2	123.93	132.6	22.72	21.6	295.71	290.81	14.6	14.35	27.64	25.57	7.25	7.72	8.38	6.18
3	123.90	128.93	22.08	21.28	273.83	295.30	18.9	8.20	29.62	26.05	5.25	1.67	3.82	2.74
3a		124.44		21.79		265.80		14.50		29.55		2.90		3.82
Ave.	123.92	128.65	22.40	21.56	284.47	283.97	16.75	12.35	28.63	27.05	6.82	3.55	5.34	4.28
4											5.95	5.35	2.38	2.02
5											8.30	8.37	5.51	4.00
5a											7.07		4.15	
6	39.78	43.5	17.44	13.92	67.7	70.2	8.0	7.65	21.0	20.35	9.0	6.35	4.55	3.76
7	44.88	45.4	14.4	12.8	78.67	67.74	11.4	11.55	20.2	20.46	6.52	5.35	4.98	3.88
8	40.29	50.49	16.32	15.84	69.7	74.69	7.6	7.00	19.72	22.54	6.57	5.25	3.00	3.96
9	43.86	51.0	20.32	17.60	91.52	98.56	8.5	8.15	22.88	22.09	7.75	5.75	4.14	2.59
Ave.	42.2	47.59	17.12	15.24	76.90	77.79	9.08	8.59	[illegible].95	41.35	7.31	6.07	4.19	3.72
10											3.42	3.02	6.26	5.05
10a											4.05		6.23	
11											2.90	3.22	4.93	4.36
12	54.57	50.49	14.08	10.08	108.67	113.3	8.5	8.45	20.45	27.5	4.25	1.65	4.84	3.40
13	52.55	43.33	16.48	8.32	104.35	83.74	10.15	5.60	22.41	16.79	3.80	1.65	5.41	5.47
14	58.65	53.55	20.46	13.76	133.12	119.55	12.0	7.95	22.0	20.71	4.65	2.05	6.90	3.61
15	64.26	56.10	16.32	10.88	132.55	118.93	8.15	6.90	23.63	27.25	3.80	1.87	5.65	3.81
Ave.	57.59	50.85	16.83	10.76	119.72	108.83	9.70	7.22	22.12	23.06	4.12	1.80	5.70	4.07

Discussion

An examination of table I indicates that the findings of this study are in general accord with those who report that there is no significant change in blood chlorides following adrenaline administration. The average value for 41 rats injected with varying amounts of adrenaline was found to be 520.2 mg. NaCl per 100 ml. of blood; the corresponding value for 36 control animals was 519.8 mg.. This variation is within the limit of experimental error for the method. In 14 chickens the injection of adrenaline caused an increase of 8.3 mg. NaCl in the total chlorides, a decrease of 6.2 mg. in the plasma chlorides, and a decrease of 5.3 mg. in the cell chlorides. These changes are not large enough to be particularly significant; they indicate that there might be a slight hydremia accompanied by a small decrease in plasma and cell chlorides.

Table II shows the effect of adrenaline on the phosphorus distribution of the blood. The total phosphorus in the whole blood is increased in chickens and rats and decreased in rabbits. This is apparently due to the decrease in the cell-plasma ratio in the experimental rabbits. More determinations would have to be made before it would be possible to state whether this was due to individual variation or to the adrenaline. There is a significant decrease in the total plasma phosphorus in rats and rabbits; the decrease in the case of chickens is less marked. The total phosphorus of the cells is not significantly affected except in rabbits, in which a decrease was observed. The lipoid phosphorus of the plasma is reduced in chickens and rabbits, and to a lesser degree in rats; the cell lipoid phosphorus is not changed significantly. The observations of those who report a decrease in the inorganic phosphorus are confirmed by a consistent diminution of the inorganic phosphorus in the plasma and, to a lesser extent, in the cells of

the animals injected with adrenaline.

Cori and Cori (6) have investigated the effect of insulin and adrenaline on the hexosephosphate content of the muscle and find that adrenaline causes a marked increase in the amount present in the muscle of rats and rabbits. They further report (7) that there is an increase in the lactic acid content of the blood following adrenaline injection. Since it is generally held that lactic acid is produced by the decomposition of muscle glycogen, it seems logical to assume that the effect of adrenaline is to increase the rate of this decomposition. Phosphorus, probably in the form of hexosephosphates, is believed by most investigators to take part in the decomposition of muscle glycogen. It seems reasonable to suppose, therefore, that at least a part of the decrease of inorganic phosphorus of the blood may be accounted for in the increased formation of muscle hexosephosphates. The decrease in inorganic phosphates in the blood may cause a hydrolysis of the lipoid-bound phosphates by the phosphatase present in the tissues. This would account for the decrease in the lipoid phosphorus of the plasma.

Conclusions

1. Adrenaline injected subcutaneously into rats, rabbits, and chickens does not affect significantly the total chloride content of the blood; there is, likewise, no marked change in the plasma and cell chlorides.

2. Adrenaline causes changes of doubtful significance in the total phosphorus in the whole blood. The total plasma phosphorus is usually decreased; the total cell phosphorus remains practically constant. The lipoid phosphorus of the plasma shows a decline, while the cell lipoid-bound fraction is unaffected.

3. There is a marked reduction in the inorganic phosphorus fraction in both plasma and, to a lesser extent, in cells.

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