TABLE II. Total Leucocyte Counts on Heparinized Blood from 12 Guinea Pigs Sensitized with Hemoglobin Suspension.

Sex	Days inc. (*In vitro* shock)	Blood + normal saline				Blood + hemoglobin antigen				Days inc. (*In vivo* shock)	Result shock dose
		Immed.	30″	60″	120″	Immed.	30″	60″	120″		
		3650	3100	2800	2975	2525	3275	3250	2575	Acc. hemorrhage	
		6325	5725	7200	6275	5450	5350	5250	5300		
♀	20	3225	3525	4375	3700	3125	2925	3425	3300		
		6325	6075	6625	6475	6075	5025	5600	5575	25	Fatal
		10550	8400	9550	9375	10200	9425	8475	8625		
		7675	8000	7650	8325	8350	7675	7350	8225		
		8425	7125	7600	7400	8350	7975	7425	8000		
♂	21	8500	7325	6250	6475	7375	7100	7225	6700	25	No shock
		5550	5375	6200	6525	5175	5725	6250	5950		
		8450	9700	9125	10325	8225	9150	9150	9275	Acc. hemorrhage	
♂*(1)	32	5825	6275	5525	6500	5550	4950	5950	5550	32	Fatal
♂*(2)	32	5575	4825	5500	5025	5275	5150	4825	4525	32	Mild shock
	Mean	6673	6288	6536	6615	6306	6144	6181	6133		

* Last 2 guinea pigs counted 2 additional hr. (Additional .4 ml saline and antigen added to respective tubes.) Values follow:

	Blood + normal saline		Blood + hemoglobin antigen	
	180″	240″	180″	240″
(1)	5025	4975	4325	4700
(2)	4625	4525	4150	4150

the non-sensitized pigs as related to leucocyte lysis in shock is not clear.

Summary and conclusions. Twelve guinea pigs were sensitized with dog hemoglobin. Subsequently blood specimens were taken and heparinized and a portion of these specimens mixed with the antigen. White cell counts were done immediately after mixing, and repeated at 30, 60, and 120 minutes. In 2 cases counts were also made at 180 and 240 minutes. Controls of blood and saline in the same ratio as blood and antigen were counted concomitantly on each guinea pig. Blood specimens from 10 non-sensitized guinea pigs were similarly collected and counted. No significant difference in the total white cell counts from sensitized or non-sensitized animals either when mixed with saline or with the hemoglobin antigen was detected. The total mean white cell count of the sensitized animals in this series was 32.7% and 34.0% above that of the non-sensitized animals in the control and experimental tubes respectively. The above findings indicate that *in vitro* lysis of sensitized guinea pig leucocytes by dog hemoglobin antigen does not occur.

1. Squier, T. L., and Lee, H. J., *J. Allergy,* 1947, v18, 156.

2. Franklin, William, and Lowell, Francis C., *J. Allergy,* 1949, v20, 375.

3. Berkson, J., Magath, T. B., and Burn, M., *Am. J. Phys.,* 1940, v128, 309.

Received January 24, 1952. P.S.E.B.M., 1952, v80.

Effect of Electroconvulsive Shock on Adrenal Cortex of the Rat.* (19522)

H. ENGER ROSVOLD, SYLVAN J. KAPLAN,† AND JAMES A. F. STEVENSON.‡
(Introduced by John F. Fulton.)

From the Laboratory of Physiology and Department of Psychiatry, Yale University.

In accounting for the effects of electroconvulsive shock in disrupting the maternal be-

* Supported by a grant from the Veterans Administration.

† Now at USAF SAM Primate Laboratory, University of Texas, Austin.

‡ Now at University of Western Ontario Medical School, London, Ontario, Canada.

havior of white rats, Rosvold(1) proposed that many of the behavioral disturbances arise directly or indirectly from endocrine disorders brought on by electroshocks. That some endocrines actually are affected was demonstrated by Bacon and Rosvold(2) who found abnormalities in the pituitary and ovaries following a series of electroconvulsions. The changes in the pituitary suggest that the adrenal gland also might be affected. If the behavioral disturbances are related to endocrine dysfunction(1), these changes in the adrenal should occur under conditions of electroshock similar to those used in the behavior studies. Experiment I tests this hypothesis.

Porter and Stone(3), Siegel, McGinnies, and Box(4); Stone and Walker(5), demonstrated that some of the disruptive effects of electroconvulsions on the rat's behavior can be avoided by anesthesia of the rat during shock. The proposition that the disturbances in behavior are directly related to endocrine dysfunction would be strengthened if the adrenal changes were avoided under conditions of electroshock in which the behavioral effects did not occur. Experiment II tests this hypothesis.

Exp. I. *Animals.* Thirty-one adult male and 19 adult female albino rats of the Sprague-Dawley strain similar in body weight were housed in individual cages in a room in which the temperature was approximately 80°. They were maintained on laboratory fox chow and water *ad libitum.*

Shock procedure. The electroshock equipment was similar to that designed by Hayes (6) and used in the Stanford and McGill laboratories in studies of the effects of electroconvulsive shock on learning, maternal behavior, and pregnancy. It was powered by 110 volts A.C. and consisted essentially of a transformer delivering a 1500 volt secondary current, a 200 millisecond timer, and a 26,000 ohm resistor in series with the rat. The rat received approximately 50 ma for 0.2 second through alligator clips fastened to the ears. These conditions invariably produced in the normal rat a generalized convulsion of the type described as tonic-clonic by Golub and Morgan(7). One group of 15 male and one of 10 female rats received electroconvulsive shocks through clip electrodes fastened to the ears. A control group of 16 males and one of 9 females had the electrodes clipped to the ears, but no current was delivered. Each of the shock groups received shock once per day for 10 days. Twenty-four hours after the last electroconvulsive shock, all the animals were anesthetized with nembutal and the adrenal glands removed, cleaned and weighed. The adrenals of 6 controls and 6 shocked animals were placed in metaphosphoric acid for determination of ascorbic acid content.

TABLE I. Mean Wt (in mg) of Adrenals of Shock and Control Groups.

Group	No. of animals	Means	$S.E._M$	P value of M. diff.
1. Shock	15 ♂	25.9	1.61	<.01
2. No shock	16 ♂	20.1	.55	
3. Shock	10 ♀	34.2	1.09	<.01
4. No shock	9 ♀	29.2	.64	
5. Shock	10 ♂	26.7	1.19	<.01
6. Shock and ether	8 ♂	19.6	.73	
7. Shock	10 ♂	26.7	1.19	<.02
8. Shock and nembutal	9 ♂	23.2	1.04	
9. Ether	8 ♂	20.2	.78	>.05
10. Shock and ether	8 ♂	19.6	.73	
11. Nembutal	9 ♂	23.2	1.25	>.05
12. Shock and nembutal	9 ♂	23.2	1.04	

Results. Table I (rows 1-4) shows the comparison of adrenal weights of control groups and shock groups. It is clear that a series of electroconvulsive shocks results in hypertrophy of the adrenal glands in both sexes. Since the milligram per cent of ascorbic acid in the adrenals of the shocked rats is not significantly different from that of the control ($t = .14$ $p > .05$), it may be that the hypertrophy is associated with increased secretory function in the manner described by Sayers(8) for his type 2 stress.

Exp. II. *Animals and procedures.* Forty-four male adult albino rats of the Sprague-Dawley strain similar in body weight were maintained and, when indicated, shocked as described in Exp. I. Eight received shock during ether anesthesia and nine during nembutal anesthesia. Ten controls received shock without anesthesia; while 8 controls were

anesthetized with ether but not shocked, and 9 anesthetized with nembutal but not shocked. Ether was administered to each rat individually by inserting the rat's head in a small bottle containing cotton saturated with ether. Nembutal was administered by intraperitoneal injection in about .3 cc doses calculated to contain 4.5 mg of nembutal per 100 g of body weight. Surgical anesthesia was always achieved before the rat was shocked. Such rats behaved like those described by Porter and Stone(3) in that the generalized epileptiform convulsion was absent, and the post convulsive period was more like rats recovering from anesthesia than shock. Twenty-four hours after the last shock in a series of 10, all the rats were anesthetized with nembutal and the adrenals removed, cleaned and weighed.

Results. Table I (rows 5-8) contains the data for a comparison of adrenal weights of shocked animals with those shocked during anesthesia. The adrenals of animals receiving electroshocks are significantly larger than those shocked during ether or nembutal anesthesia. The data in rows 9-12 of Table I indicate that there is no reliable difference in the size of the adrenals between those animals shocked under anesthesia, and the controls anesthetized but not shocked, demonstrating that the differences shown in rows 5-8 are not an artifact of the effect of anesthesia on the adrenals.

Conclusion and discussion. An effect of a series of 10 electroshocks is to increase the size of the rat's adrenals. This effect is inhibited if the shocks are administered during anesthesia of the rat. Since the behavioral effects of electroconvulsive shock occur or are inhibited under circumstances in which the effects of electroshocks on the adrenal cortex occur or are avoided it is reasonable to assume that in the rat the behavioral and endocrine effects are related. That the same relationship between the adrenal cortex and behavior may hold for humans is suggested in studies by Hoagland *et al.*(9,10), and recently by Graham and Cleghorn(11) who demonstrated that the clinical condition of psychotic patients during a course of electroshock therapy may be reflected in the function of the adrenal cortex.

Summary. Hypertrophy of the rat's adrenal glands has been shown to follow a series of electroconvulsive shocks administered under conditions known to disturb behavior. The adrenal enlargement was avoided by administering the series of shocks during anesthesia of the rat, a circumstance known to inhibit the behavioral disturbances following a series of electroconvulsive shocks. The coincident changes in adrenal size and in behavior suggest that the endocrine changes may mediate the effects of electroconvulsive shocks on the behavior of the rat.

1. Rosvold, H. E., *J. Comp. Physiol. Psychol.*, 1949, v42, 207.

2. Bacon, R. L., and Rosvold, H. Enger, PROC. SOC. EXP. BIOL. AND MED., 1948, v69, 287.

3. Porter, Paul B., and Stone, Calvin P., *J. Comp. Physiol. Psychol.*, 1947, v41, 441.

4. Siegel, Paul S., McGinnies, Elliott M., and Box, Jane C., *J. Comp. Physiol. Psychol.*, 1949, v42, 417.

5. Stone, Calvin P., and Walker, Alan H., *J. Comp. Physiol. Psychol.*, 1949, v42, 429.

6. Hayes, Keith J., *J. Comp. and Physiol. Psychol.*, 1948, v41, 40.

7. Golub, L. M., and Morgan, C. T., *J. Nerv. Ment. Dis.*, 1945, v38, 239.

8. Sayers, G., and Sayers, M. A., *Annals N. Y. Acad. Sci.*, 1949, v51, 522.

9. Hoagland, H., Malamud, W., Kaufman, I. C., and Pincus, G., *Psychosomatic Med.*, 1946, v8, 246.

10. Hoagland, H., Callaway, E., Elmadjian, F., and Pincus, G., *Psychosomatic Med.*, 1950, v12, 73.

11. Graham, B. F., and Cleghorn, R. A., *J. Clin. Endocrinol.*, 1951, v11, 1469.

Received March 10, 1952. P.S.E.B.M., 1952, v80.