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ELECTRIC SHOCK THERAPY

CLINICAL, BIOCHEMICAL AND MORPHOLOGIC STUDIES

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The purpose of this communication is to summarize our clinical observations and to describe more comprehensively studies of the blood and urine made immediately before treatments and at short intervals after convulsions.

CLINICAL OBSERVATIONS

Tolerance.—The following observations on the threshold for convulsions appear to be noteworthy: With 1 patient, three attempts made at five minute intervals to induce a convulsion by application of a current of 450, 500 and 550 milliamperes respectively for three-tenths second in the first treatment and two attempts by application of a current of 500 and 550 milliamperes for five-tenths second in the second treatment were followed by momentary loss of consciousness; five minutes later 600 milliamperes given for five-tenths second caused a severe convulsion, which lasted forty-five seconds. In the third treatment 650 and 675 milliamperes, again given at an interval of five minutes, induced only momentary loss of consciousness. In the fourth treatment 625 milliamperes given for five-tenths second induced a severe convulsion of forty-five seconds' duration. In the fifth and sixth treatments application of 600 milliamperes for five-tenths second also caused severe convulsions of sixty and forty seconds' duration respectively. In another patient 500 and 600 milliamperes given for three-tenths second evoked convulsions. In the third treatment four attempts with application of 600 milliamperes for three-tenths second were followed by four petit mal attacks. In the fourth treatment 600 milliamperes given for three-tenths second again caused a petit mal reaction; five minutes later only 300 milliamperes, but applied for five-tenths second, induced a major convulsion. In a third patient 450 milliamperes, given in two treatments for three-tenths and five-tenths second respectively, produced well pronounced convulsions; then two successive treatments with 450 milliamperes each, one treatment with 500 milliamperes and another with 550 milliamperes, each given for three-tenths second, were followed by petit mal attacks. Because the patient complained of nausea, no further attempt was made to induce a convulsion. In a fourth patient, in the first treatment, three attempts with 350 milliamperes and two attempts with 450 milliamperes, given for three-tenths and for five-tenths second respectively at intervals of five minutes, caused petit mal reactions. In the second treatment three attempts with 450, 550 and 600 milliamperes respectively for five-tenths second also produced only petit mal seizures; the fourth trial, with 600 milliamperes for five-tenths second, caused a fully developed convulsion of fifty seconds' duration. In a fifth patient 300 milliamperes given for three-tenths second produced a petit mal reaction. Then, three treatments with 350 milliamperes each for three-tenths second were followed by convulsions. In the fourth treatment three applications of 350, 400 and 450 milliamperes respectively for three-tenths second caused only petit mal attack, but in the fourth trial 450 milliamperes for three-tenths second produced a convulsion of sixty seconds' duration.

These cases illustrate our common observation that the patient's tolerance of the electric current may change at intervals of a few days or a few minutes. The tolerance may remain consistently high, though undergoing changes; it also may diminish considerably within a few minutes. To one of us (C.) atmospheric conditions had appeared to have a bearing on the dosage; on a dry, clear day a higher current was required than on a humid day. On the other hand, we also observed notable changes in the tolerance of the electric current in the same patient within a few minutes when atmospheric conditions appeared to be the same. Both change and consistency in the threshold for convulsions were observed with nearly equal frequencies throughout the treatments.

Reactions to the Electric Current.—A survey of the immediate reactions of our patients to the passage of the electric current revealed the fol-

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lowing facts: The latent period was commonly three to five seconds, and only occasionally twenty to thirty seconds. Petit mal reactions were observed with application of currents of from 350 to 675 milliamperes for three-tenths second. Their frequency was nearly the same with currents of from 350 to 450 milliamperes, 450 to 500 milliamperes and 500 to 550 milliamperes, and was notably less with currents of from 550 to 600 milliamperes. Severe and moderate convulsions were observed with a current of 300 to 600 milliamperes. However, with higher currents the frequency of severe convulsions greatly increased. With a current of 600 milliamperes given for three-tenths second the convulsions were severe in the large majority of treatments in the same and in different patients.

In some of the patients the reactions to the electric currents were unusual: One patient reacted to 550 milliamperes given for five-tenths second with the usual convulsion. He appeared relaxed for a minute or so; then he had another convulsion, though less severe and of shorter duration. With another patient the duration of the convulsion was remarkably long, namely, fifteen minutes with 500 milliamperes, three minutes with 600 milliamperes and six minutes with 300 milliamperes. One of our patients during the first three treatments reacted with jacksonian-like convulsions: After a latent period for about twenty-five seconds, the patient slowly turned his head to the left; his eyes and tongue deviated also to the left; then the fingers of both hands began to twitch; this was immediately followed by convulsive movements of the right side of the body and by a few clonic movements on the left side. After the convulsion there was a noticeable diminution in the muscular tonus on the left side as compared with that on the right side. In 1 patient a convulsion of fifty seconds' duration in the fourth treatment was followed by apnea for six minutes. With administration of nikethamide and artificial respiration regular breathing was reestablished.

Postconvulsive Reactions.—Nausea with or without vomiting was experienced by a few patients. Fear of the treatment was noted occasionally. One patient after the fifth treatment complained of being afraid of the treatments. Headache, from which he suffered after the preceding two treatments, may have been one of the reasons for his fear. Another patient, after a petit mal seizure, bade those around him good-by and said that he expected to die soon. Five minutes later he reacted with a convulsion to an increased dose; when he came out of the seizure, he complained of headache and expressed the belief that he was already dead. One of us (S.K.) and associates [1] had previously observed a similar reaction in a patient during metrazol treatment.

Complications. — Complications occurred in only a few of our 276 patients. Three had fractures of the head of the humerus. In 1 of them the fracture occurred during the third treatment. The patient felt greatly improved and was content to have his shoulder broken rather than to suffer the depression. Five patients had vertebral fractures. Curare was given prior to the treatment of 17 patients. One patient had fracture of the femur at the site of a former fracture; the first fracture had been followed by a severe depression.

THERAPEUTIC RESULTS

The therapeutic results obtained in 276 patients are summarized in table 1.

The relatively large number of patients in the schizophrenic group is due in part to the fact that it includes schizophrenic patients with prominent affective reactions—depression, tension and agitation—and with behavior and feeding problems. On the other hand, we were interested in trying out the treatment on schizophrenic patients without pronounced affective disturbance. Patients with essentially or prominently depressive reactions were included with the patients suffering from manic-depressive, involutional and undifferentiated psychoses, and a number of them, as just mentioned, were placed in the schizophrenic group. The relatively high rate of "recovery" and "improvement" among the last-mentioned patients is to be accounted for, largely, by the therapeutic results obtained in schizophrenic patients with depressive features. However, apparent "recovery" or "improvement" was obtained, also, in patients with fully

TABLE 1.—*Results of Electric Shock Therapy for Two Hundred and Seventy-Six Patients*

Diagnosis	Number of Patients	Patients Recovered	Patients Showing Improvement	Patients Showing No Improvement
Dementia precox (schizophrenia)	167	43	55	69
Manic-depressive psychosis, depressive type	60	32	16	12
Involutional psychosis (melancholia)	21	6	11	4
Undifferentiated psychoses (schizophrenic-affective features)	19	9	4	6
Psychoneurosis	9	0	5	4

1. Katzenelbogen, S.; Brody, M. W.; Hayman, M., and Margolin, E.: Metrazol Convulsions in Man, Am. J. Psychiat. **95**:1343, 1939.

loped schizophrenia, chiefly in the acute se of their illness. Relapses among schizo- nic patients with depression were much more uent than among essentially depressed pa- ts. It is noteworthy that in some patients a condition diagnosed as manic-depressive ression the treatment was followed by lifting he depressive features and, as it were, by ging to the fore of the schizophrenic reac- s. It appears as though the latent schizo- nic condition was covered by the depression. f the patients who were difficult to manage, e with suicidal or homicidal tendencies and e dependent on tube feeding, the treatment helpful to some, not only in ameliorating behavior, but in leading to "recovery" and provement." Thus, of 28 of such patients, recovered" and 7 showed "improvement." [2] e catatonic patients came out of their mutism behaved as though recovered after only three ments.

is interesting to note that in general our nts showed improvement more frequently not after only three or four treatments.

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pecimens of urine and of blood from the arm were obtained before and after treatment the patients, who were given no breakfast.

rine.—The acid reaction of the urine re- ed unchanged after treatment in 38 of 45 nces. In 1 instance the reaction turned neutral to acid after treatment; in 3 in- es, from alkaline to acid, and in 3 instances, acid to alkaline. In 46 instances the specific ty showed significant changes after treat- In 45 instances the reaction for sugar negative within one hour and forty-five tes after treatment. There was a trace of before and none within one hour after ment in 2 instances. In 43 instances the ion for albumin was negative within one after treatment; there was a trace after ment in 4 instances and a 2 plus reaction treatment in 6 instances. Microscopic ex- ation revealed nothing abnormal.

ood.—The methods of analyses used in this have been described in the articles cited.[3]

Changes in the constituents of the blood following convulsions are summarized in tables 2 and 3.

Both the cellular and the chemical constituents of the blood (amino acids, cholesterol, vitamin C, reducing substances, oxygen, total phosphorus, organic phosphorus, acid-soluble phosphorus, inorganic phosphorus, chlorides, sodium, potassium, calcium and magnesium), as well as the icteric index, showed changes after treatment; increases often being more frequent than decreases, except for the amino acids, which showed a decrease more than twice as frequently as an increase, and carbon dioxide, which was decreased after nearly all treatments.

TABLE 2.—*Sedimentation Rate and Morphologic Constituents of the Blood Which Showed Changes After Electrically Induced Convulsions* *

	Total No.	Treatments: Increase	Treatments: Decrease	Treatments: No Change
Red cells	41	27 (90,000 to 1,770,000)	13 (70,000 to 1,850,000)	1
White cells	41	25 (100 to 5,500)	16 (30 to 2,550)	..
Segmented neutrophils	31	14 (6 to 24%)	15 (4 to 24%)	2
Lymphocytes	29	14 (5 to 24%)	13 (6 to 20%)	2
Monocytes	26	15 (2 to 4%)	6 (1 to 4%)	5
Eosinophils	31	3 (1%)	5 (1%)	23
Sedimentation rate	33	20 (4 to 8 mm.)	12 (1 to 12 mm.)	1

* These changes appeared within one hour after convulsion.

COMMENT

Changes in many treatments were not great enough to be important in themselves; yet they gave significance to the more conspicuous alterations in that they emphasized a definite trend. Of the chemical constituents of the blood which undergo changes in the already old-fashioned insulin and metrazol therapies, the reducing substances, oxygen and carbon dioxide have been singled out as the most significant. The therapeutic effects of both these treatments have been attributed to anoxemia, induced by hypoglycemia in insulin therapy and, presumably, by lack of oxygen in metrazol therapy.[4] In convulsive

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4. Himwich, H. E., and Fazekas, T. F.: The Effect of Hypoglycemia on the Metabolism of the Brain, Endocrinology **21**:800, 1937. Himwich, H. E.; Bowman, K. M.; Wortis, J., and Fazekas, J. F.: Metabolism

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therapy, it should be borne in mind that the deficiency of oxygen in the blood is limited to a short period of apnea during the tonic phase of the convulsions, and that in other phases there is hyperpnea, with corresponding increase of oxygen and decrease of carbon dioxide. But after the convulsion (especially within twenty minutes) in both metrazol and electric shock therapy, there is almost consistently an increase in the oxygen and reducing substances and a decrease in the carbon dioxide in the blood. Thus, if the therapeutic results in convulsive therapy are to be ascribed specifically to changes in the oxidative processes, it would seem appropriate to speak of hyperoxemia rather than of anoxemia.

In trying to understand the mode of action of shock therapies on the physiologic level, one should be cognizant of the fact that change in oxidative processes is not the only effect. Other metabolic alterations take place at the same time, as shown by previous morphologic and chemical studies [6] and by the present investigation. Prominent in the shock therapies considered in this study are the clinical reactions, the laboratory evidences of disturbance in the function of the vegetative organs and the metabolic changes. Thus, both clinical and laboratory observations are indicative of profound disturbances in the physiologic function of the person, in the vital organs and in the metabolism, which disturbances show a definite trend toward hyperactivity. Similar reactions of the person, of the organs and of the general metabolism are prominent in nonspecific protein therapy. It is not far fetched to postulate that the mode of action, namely, activation of the function of organs, attributed with good reason, I believe, to the nonspecific protein therapies [5] is equally applicable to the nonspecific shock therapies. But it should be added that the physiologic aspect is not alone to be considered. Multiple psychotherapeutic factors enter into the drama of any of the shock therapies, and contribute their share to the outcome.

TABLE 3.—*Chemical Constituents of the Blood Which Showed Changes After Electrically Induced Convulsions* *

		Total No.	Treatments: Increase	Treatments: Decrease	No Change
Amino acids		50	16 (0.48 to 1.52 mg./100 cc.)	34 (0.49 to 3.19 mg./100 cc.)	..
Icteric index		19	9 (1.7 to 3.3 units)	..	10
Cholesterol		83	60 (8.2 to 91.2 mg./100 cc.)	23 (5.0 to 60.6 mg./100 cc.)	..
Vitamin C		74	57 (0.15 to 0.68 mg./100 cc.)	15 (0.1 to 0.23 mg./100 cc.)	2
Reducing substances		67	60 (11.0 to 72.3 mg./100 cc.)	2 (12.1 to 23.4 mg./100 cc.)	5
Oxygen		68	50 (4.13 to 12.28 vol. %)	16 (3.54 to 12.64 vol. %)	2
Carbon dioxide		67	3 (2.13 to 6.22 vol. %)	64 (5.29 to 33.68 vol. %)	..
Total phosphorus	Serum	19	15 (1.0 to 5.8 mg./100 cc.)	1 (0.3 to 12.1 mg./100 cc.)	3
	Cells	21	12 (0.8 to 6.8 mg./100 cc.)	8 (0.7 to 4.9 mg./100 cc.)	1
Organic phosphorus	Serum	18	12 (0.4 to 5.0 mg./100 cc.)	6 (0.2 to 9.0 mg./100 cc.)	..
	Cells	19	5 (0.4 to 11.6 mg./100 cc.)	14 (0.3 to 12.5 mg./100 cc.)	..
Acid-soluble phosphorus	Serum	20	16 (0.1 to 4.4 mg./100 cc.)	3 (0.1 to 2.8 mg./100 cc.)	1
	Cells	24	10 (0.6 to 3.0 mg./100 cc.)	13 (1.3 to 5.5 mg./100 cc.)	1
Inorganic phosphorus	Serum	52	45 (0.5 to 2.9 mg./100 cc.)	6 (0.1 to 1.3 mg./100 cc.)	1
	Cells	54	48 (1.2 to 8.3 mg./100 cc.)	6 (0.2 to 1.1 mg./100 cc.)	..
Chlorides	Serum	35	21 (5.7 to 19.9 mg./100 cc.)	12 (1.4 to 10.7 mg./100 cc.)	2
	Cells	36	34 (8.5 to 49.0 mg./100 cc.)	..	2
Sodium	Serum	92	67 (5.5 to 20.6 mg./100 cc.)	25 (3.2 to 27.6 mg./100 cc.)	..
	Cells	27	27 (4.2 to 25.6 mg./100 cc.)	..	..
Potassium	Serum	87	56 (5.7 to 22.8 mg./100 cc.)	30 (1.1 to 12.19 mg./100 cc.)	1
Magnesium	Serum	28	20 (0.2 to 1.2 mg./100 cc.)	8 (0.1 to 0.5 mg./100 cc.)	..
Calcium	Serum	41	27 (0.2 to 1.7 mg./100 cc.)	13 (0.1 to 1.1 mg./100 cc.)	1

* These changes were determined within eighty-six minutes after the convulsion.

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of the Brain During Insulin and Metrazol Treatment of Schizophrenia, J. A. M. A. **112**:1572 (April 22) 1939.

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