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Changes in Blood Chemistry in Rats Following Electrically-Induced Seizures.*

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A maximal seizure consists of violent neural and muscular activity lasting many seconds and might be expected to involve considerable changes in brain and blood chemistry. Klein and Olsen[1,2] found that 10 seconds of convulsive activity accelerates the glucose metabolism of brain and results in an approximately two-fold increase in brain lactate and a decrease in high-energy phosphate bonds. McLaughlin and Hurst[3] observed moderate decreases in plasma pH and alkali reserve and corresponding increases in blood lactate, and others[4-7] have found increases in plasma phosphate following idiopathic convulsions in humans. The post-convulsive depression and other sequelae of seizures may be the result of metabolic activity occurring during seizures. In order to determine the magnitude and duration of chemical changes occurring in a commonly used experimental animal, the work presented here was undertaken.

Methods. Adult male rats of the Sprague-Dawley strain were used. Maximal seizures were induced by passing a 150 mA current of 0.2 secs duration between Spiegel corneal electrodes.[8] Blood was obtained by heart puncture, and heparin was used as an anticoagulant. Plasma was separated anaerobically by the method of Davenport.[9] Its pH was determined by means of a standardized glass electrode, and its carbon dioxide by the method of Van Slyke and Neill.[10] Plasma lactate was determined by the method of Barker and Summerson,[11] and plasma inorganic phosphate was determined by the method of Fiske and SubbaRow.[12] Plasma sodium and potassium were estimated by means of a Perkin-Elmer flame photometer (Model 52A) with internal lithium standard.

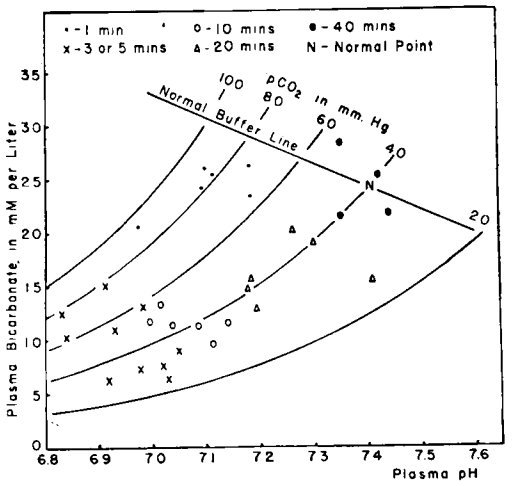

FIG. 1.
pH-bicarbonate diagram showing blood acid-base changes following maximal seizures in rats.

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TABLE I.
Concentrations of Electrolytes in Rat Plasma Following Maximal Electroshock Convulsions.

Time after convulsions, min.	Lactate, mEq/l	Phosphate, mM/l	Sodium, mEq/l	Potassium, mEq/l
Control	3.1 ± 0.2* (12)	1.9 ± 0.1 (8)	142.5 ± 0.1 (12)	4.8 ± 0.2 (12)
1	20.8 ± 1.9 (6)	3.4 ± 0.3 (6)	155.1 ± 1.1 (6)	5.1 ± 0.1 (6)
5	20.3 ± 1.5 (6)	2.8 ± 0.3 (6)	151.1 ± 0.6 (6)	4.4 ± 0.1 (6)
10	—	—	147.2 ± 0.2 (6)	4.0 ± 0.2 (6)
20	11.1 ± 1.6 (6)	2.5 ± 0.1 (6)	147.3 ± 1.1 (6)	3.8 ± 0.2 (6)
40	3.9 ± 0.5 (6)	2.1 ± 0.1 (6)	140.6 ± 0.4 (5)	4.6 ± 0.1 (5)
60	3.7 ± 0.6 (6)	1.8 ± 0.1 (6)	—	—

* Standard error of the mean.

Results. The plasma pH and bicarbonate concentration, observed at intervals after seizures, are plotted on the pH-bicarbonate diagram shown in Fig. 1. The plasma lactate, phosphate, sodium and potassium concentrations are given in Table I.

One minute after a maximal seizure, respiratory acidosis was present, the pCO_2 averaging 80 mm Hg. There was also a severe metabolic acidosis. Total extra fixed-acids of the blood were greater than 20 mEq/l, and the sodium concentration had risen 12 mEq/l. At the end of 5 minutes the respiratory acidosis had disappeared; but the metabolic acidosis was still extreme, and all observed pH values were below 7.05. Thereafter the metabolic acidosis became progressively less severe until recovery was attained at 40 minutes. Simultaneously the plasma sodium concentration returned to normal, and the plasma potassium concentration fell slightly below normal.

Discussion. The metabolic changes produced by a maximal seizure can be explained by the vigorous muscular activity and cessation of respiration occurring during the convulsion. The acidosis is as severe as that observed in completely uncontrolled diabetes mellitus, and the rise in sodium concentration is equal to that produced by overdosage with desoxycorticosterone acetate.[13] It is likely that the metabolic changes, rather than purely electrical events, in the brain, account for most of the post-seizure depression whose time course parallels that of the chemical changes in the blood.[8] Extreme metabolic acidosis, produced by ammonium chloride, itself reduces the excitability of the brain as measured by an increase in electroshock threshold.[14] A rise in plasma sodium concentration is similarly associated with reduced cerebral excitability.[13] If similar changes occur in humans undergoing electroshock therapy of psychotic disorders, it would appear important to investigate the relative contributions of the changes in brain and blood chemistry and the electroshock itself to the salutary results of the treatment.

Summary. Severe respiratory and metabolic acidosis, accompanied by increases in plasma lactate, phosphate and sodium concentrations, occur in rats following maximal electrically-induced seizures. Recovery is complete in 40 minutes. It is suggested that the profound chemical changes occurring during the seizure may contribute to the post-ictal depression.

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