the first month, 8 out of 17 at the end of the second month, and 11 out of 16 fed for 3 months. Maximum agglutination (1-320) was ordinarily demonstrated within 3 or 4 hours although reactions could be read when tubes were held overnight.

Portions of the serum obtained before and during feeding were inoculated with the various yeasts fed and held at body and at room temperatures. In this study blood serum was never found to exert noticeable effect upon the yeast fed when held at room temperature. Some yeasts, however, failed to develop as well as others upon transplanting to dextrose agar slants after being held in fresh blood serum at 37°C. for a period of 48 hours. That was not due entirely to any direct action of the serum itself, nevertheless, as the same yeasts also failed to develop readily when inoculated on dextrose agar slants and held at that temperature.

6189

The pH and the CO_2 Content of Cerebrospinal Fluid in Epilepsy.*

L. W. EMPEY, H. A. PATTERSON AND IRVINE MC QUARRIE.

From the Craig Colony, Sonyea, N. Y., and the Departments of Pediatrics, University of Rochester, and University of Minnesota.

Although considerable work has been done on the acid-base relationships in epilepsy, the evidence presented thus far has been conflicting and indecisive. Because of the importance of this phase of the problem, we have determined the pH and CO_2 content of the cerebrospinal fluid in 125 epileptics and 30 non-epileptic control subjects by procedures which eliminate errors due to loss of CO_2.[1, 2]

The colorimetric method of McQuarrie and Shohl[1] used for determining the pH may be briefly described as follows: The clear fluid is drawn into a special glass sampling burette over clean mercury after all air in the connecting tubes has been eliminated by means of a 3-way stop-cock. In preparation for taking the sample a number of tenths of a cc. of 0.0075% phenol red equal to the number of cc. of fluid to be taken is measured into the appara-

* The writers are grateful to Dr. W. T. Shanahan, Superintendent of Craig Colony, for his cooperation during these studies, and to Dr. Edith Boyd for assistance in the use of the statistical method.

[1] McQuarrie, Irvine, and Shohl, A. T., *J. Biol. Chem.*, 1925, **66**, 367.

[2] Van Slyke, D. D., and Neill, J. M., *J. Biol. Chem.*, 1924, **61**, 523.

tus. After the spinal fluid is mixed with the dye in this concentration, it is read directly at 38°C. against the bicolor standards of Hastings and Sendroy in a simple comparator block made to hold the sampling burette and standard tubes which have the same diameter. By slightly elevating the mercury reservoir of the sampling tube and turning the stop-cock of the latter, spinal fluid is forced into an Oswald-Van Slyke pipette. This is then measured directly into the Van Slyke and Neil[2] apparatus under mineral oil for determination of the CO_2. In the calculation of the CO_2 allowance is made for the dilution of the spinal fluid by the dye solution.

Several facts suggest that the occurrence of epileptic attacks depends at least in part upon a disturbance in the mechanisms regulating acid-base equilibrium. Certain procedures, which are often effective in preventing seizures, such as fasting,[3] the use of strongly ketogenic diets,[4, 5] and the administration of acid-forming salts or carbon dioxide,[6] tend to produce mild acidosis. On the other hand, alkalosis from hyperventilation of the lungs,[7] from administration of alkali[6, 8] or even the use of alkaline ash diets[8] favors the occurrence of seizures. Although a number of workers[9, 10] have reported evidence of an instability of acid-base balance in the blood in relation to *grand mal* attacks, others[11] have been unable to confirm this. The spinal fluid has been studied very little from this angle. Patterson and Levi,[12] using an "open" colorimetric method, found an average pH value of 7.75 in 50 cases of epilepsy. Osnato and Killian[13] found normal values in a small series of cases by use of the "closed" method of McQuarrie and Shohl.[1] Since Gesell and Hertzman[14] had shown that the pH of the cerebrospinal fluid may differ considerably from that of the blood under certain circumstances, it was thought desirable to restudy the spinal fluid in a large series of cases under uniform conditions and by means of a simple but accurate technique.

---

[3] Geyelin, H. R., *Med. Rec. N. Y.*, 1921, **99**, 1037.

[4] Wilder, R. M., *Mayo Clinic Bull.*, 1921, **2**, 307.

[5] Peterman, M. G., *Am. J. Dis. Child.*, 1924, **28**, 28.

[6] Lennox, W. G., and Cobb, Stanley, *Medicine*, 1928, **7**, 105.

[7] Foerster, O., *Deutsche Z., f. Nervenh.*, 1924, **83**, 347.

[8] McQuarrie, Irvine, and Keith, H. M., *Am. J. Dis. Child.*, 1929, **37**, 261.

[9] Jarlov, E., *Compt. rend. Soc. de biol.*, 1921, **84**, 156.

[10] Geyelin, H. R., Bigwood, E. J., and Wheatley, M. A., PROC. SOC. EXP. BIOL. AND MED., 1923, **21**, 227.

[11] Marrack, J., and Thacker, G., *Brit. J. Exp. Path.*, 1926, **7**, 265.

[12] Patterson, H. A., and Levi, P., *Arch. Neurol. and Psychiat.*, 1926, **15**, 353.

[13] Osnato, M., and Killian, J. A., *Brain*, 1927, **50**, 581.

[14] Gesell, R., and Hertzman, A. B., *Am. J. Physiol.*, 1926, **78**, 610.

Most of the epileptics examined were mildly to moderately severe institutional cases of various types, ranging in age from 6 to 18 years. The non-epileptic control subjects cannot be said to have been "normal" persons, but none of them showed signs of acute illness or other conditions likely to be associated with an abnormal acid-base balance. The group was constituted as follows: Mongolian idiocy 3, congenital hydrocephalus 3, chorea minor 2, brain tumor 3, "behavior problem" cases 5, post-encephalitic syndrome 2, congenital syphilis 4, feeble mindedness 5, post-poliomyelitic paral-

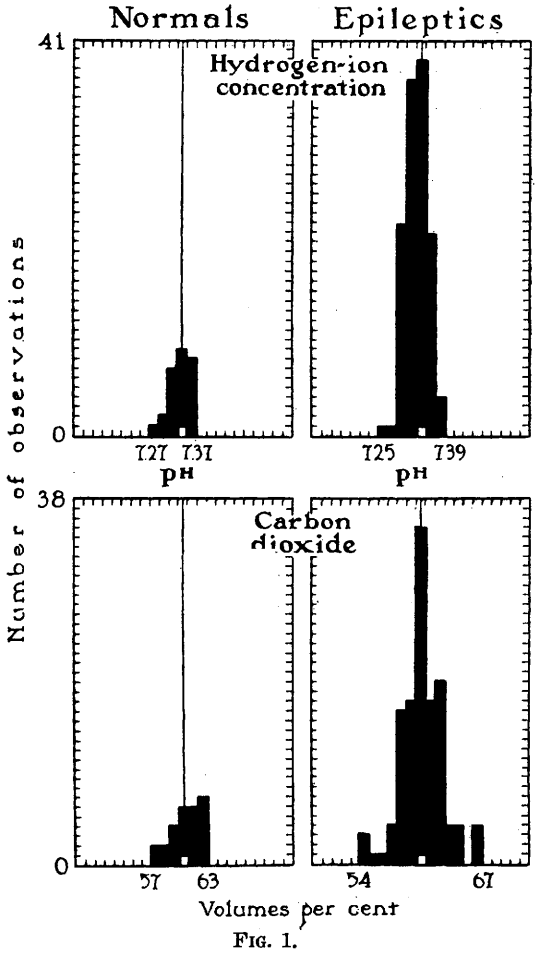

FIG. 1.

Histograms for the pH and CO_2 content of the cerebrospinal fluid in non-epileptic and epileptic subjects.

The white square indicates the mean of the frequency distribution for each constituent. The perpendicular solid line indicates the means for non-epileptic subjects.

ysis 3. All samples were taken in the morning before breakfast. Every subject examined had previously been on an ordinary mixed diet and approximately one-third of the epileptics were on phenobarbital therapy. Samples were obtained in several instances within one hour after a seizure. The shortest time interval between the lumbar puncture and a subsequent *grand mal* attack was 1.2 hours.

Figure 1 gives the results. The mean values for the pH (7.327) and the CO_2 content (60.0 vol. %) of the epileptic patients are practically identical with those found for the non-epileptic control group (pH 7.328, CO_2 60.6 vol. %). In a few non-epileptic cases in which the comparison was made, fluid taken from the lateral ventricles did not differ significantly, as regards these factors, from that obtained simultaneously by lumbar puncture. In but one epileptic and one non-epileptic was the pH reading below 7.30. This could readily be accounted for in the case of the former as a result of a severe convulsion which occurred a few minutes before the sample was taken. The pH was 7.25 and the CO_2 content 66.5 volumes percent, showing the low pH to be due in part to an accumulation of CO_2. The only low pH value (7.28) for the control group was found in the case of a mongolian idiot, who struggled violently before the lumbar puncture could be made. The maximum pH for the epileptics was 7.39, which occurred 4 times only and that for the non-epileptics 7.37, a difference well within the range of error in measurement. No values were found which would indicate the slightest tendency toward an "alkaline drift" in the spinal fluid of the epileptics. In contrast with the findings of Geyelin, Bigwood and Wheatley[10] for blood, the range of variation in pH values for spinal fluid was remarkably narrow in our series.

6190

The Electrocardiogram in Coronary Thrombosis.

FRANK N. WILSON, PAUL S. BARKER, A. GARRARD MACLEOD AND L. L. KLOSTERMYER.

From the Department of Internal Medicine, University of Michigan Medical School.

The tentative conclusions below are based upon a study of the electrocardiograms in 56 cases of coronary thrombosis, in 17 of which a post-mortem examination of the heart was made.