Electrolyte and Acid-Base Parameters of Rat Cerebrospinal Fluid*

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Summary. Values for various electrolytes and acid-base parameters of rat CSF were determined in adult animals anesthetized with pentobarbital or ether. In addition, the distribution of 5,5-dimethyl-2,4-oxazolidinedione (DMO) between CSF and arterial and venous blood was measured in the same animals. It was found a) that CSF electrolyte and acid-base parameters are the same in ether- and pentobarbital-treated animals; b) that DMO distributions between CSF and blood are not determined solely by pH gradients; and c) that in rat CSF electrolyte concentrations (mEq/l) — Na = 148.4; K = 3.16, Cl = 117.9 — and acid-base values — pH = 7.38, H₂CO₃ = 1.30 mM/l; HCO₃ = 24.5 mM/l — are very similar to those measured in other species.

Key Words: Cerebrospinal fluid — Electrolytes — pH — Acid-base — Brain

Introduction

The composition of the cerebrospinal fluid (CSF) in a number of species has been investigated rather extensively, particularly in conjunction with studies of the “blood-brain barrier”. During a series of experiments on the distribution of a number of substances including hydrogen ion and radioactive Na and Cl in the various compartments of rat brain, the need to know the normal electrolyte and acid-base status of the CSF of rats became apparent. Although the literature contains information on the composition of CSF of many mammalian and non-mammalian species, the constituents of rat CSF, other than total CO₂ (DAVSON and LUCK 1956), do not appear to have been measured. Therefore the electrolyte composition and acid-base status of rat CSF were studied, particularly as they relate to the composition of brain and plasma. The results of these experiments constitute the basis of this report.

Methods

General. The animals used were large male Sprague-Dawley rats with a mean body weight of 420 g. They were divided arbitrarily into two groups, the electrolyte group and the acid-base group. This was necessary because it was not feasible to measure both acid-base para-
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meters and electrolyte values in the CSF from a single rat. Brain, muscle, and plasma electrolytes were measured in both groups of animals and the results were compared. On the basis of these comparisons the two groups were not different.

The animals in the acid-base group were injected with 4 μc of 214C-5,5-dimethyl-2,4-oxazolidinedione (DMO) in 1 ml of 0.9% (w/v) NaCl solution two hours before sacrifice. The rats in the electrolyte group were injected with the same volume of NaCl solution. All injections were made intraperitoneally. When the tissue samples were to be taken, the rat was lightly anesthetized with either ether or pentobarbital (50 mg/kg) and was placed in a holder to facilitate withdrawal of CSF (Reed and Woodbury 1962). CSF from the cisterna magna was withdrawn into a 0.25 ml syringe lubricated with silicone grease. The size of the bore in the tip of the syringe had been increased slightly so that part of the CSF sample could be transferred to a 100 μl Hamilton syringe or a micro glass electrode, with practically no exposure to air. CSF samples of 120 to 190 μl per rat were obtained; if any blood could be detected in the sample, the sample was discarded. Immediately after removal of the CSF, a sample of arterial blood was taken from the abdominal aorta and samples of brain and muscle were removed and analyzed as described previously (Reed et al. 1964).

Electrolytes. In addition to determining the Na, K, and Cl concentrations in plasma, muscle, and brain, as referred to above, a 10 μl sample of CSF was added to a previously prepared titration medium, and Cl was measured according to the method of Cotlove et al. (1958). Also, 100 μl samples of CSF were added to a lithium-containing diluent, and Na and K were determined by flame photometry.

Acid-base Determinations and Calculations. The methods of sampling blood and CSF are described above. The pH of whole blood and CSF was measured anaerobically at 37°C in a Radiometer pH meter immediately after collection. True plasma samples for CO₂ and radioactivity determinations were obtained from blood by the method of Gardner and Davenport (1949). Aliquots of CSF for CO₂ and DMO measurements were taken directly from the sampling syringe with a gas-tight Hamilton syringe.

Total CO₂ in plasma and CSF was measured with a Fisher Clinical Gas Partitioner. The radioactivity in plasma and CSF was determined with a Tracerlab thin-window gas-flow counter. Lactic acid in plasma was measured by the method of Back and Scrox (1941).

The pH of CSF was calculated from the distribution of DMO as follows. The assumption was made that only the undissociated form of DMO could pass into the CSF from the interstitial fluid, and consequently, the concentrations of undissociated DMO in interstitial fluid and CSF were equal. The pH of CSF was then calculated from the total DMO content of CSF and the Henderson-Hasselbalch equation. The pKa for DMO in CSF was assumed to be 6.13.

Results

Electrolytes (see Table 1). The Cl concentration in CSF is higher and the Na and K concentrations in CSF are lower than in plasma. Stueck and Fisher (1961) have reported the same qualitative relations for the electrolytes of human plasma and CSF. The concentrations of electrolytes in brain and muscle are typical of the many values reported in the literature. They are included in this study for

| Table 1. Values for electrolytes of rat CSF, plasma, brain, and skeletal muscle |
|-----------------|---|---|---|---|
|                | % H₂O | Cl  | Na  | K   |
| CSF            | 99.50 | 117.9 ± 0.9 | 148.4 ± 0.8 | 3.16 ± 0.04 |
| Plasma         | 92.03 ± 0.08 | 112.2 ± 0.6 | 153.9 ± 0.5 | 4.13 ± 0.10 |
| Brain          | 78.86 ± 0.06 | 29.2 ± 0.0 | 44.6 ± 0.4 | 101.4 ± 0.4 |
| Muscle         | 76.33 ± 0.04 | 11.2 ± 0.2 | 18.0 ± 0.3 | 98.2 ± 0.1 |