THE TRANSFER OF SODIUM TO THE EXTRACELLULAR SPACE AND CEREBROSPINAL FLUID IN A NEWBORN INFANT

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In the course of experiments on the transmission of radioactive sodium across the human placenta it became necessary to examine the way in which sodium diffuses in the newly born infant. Studies of this problem have already been reported by Flexner, Wilde, Proctor, Cowie, Vosburgh and Hellman (1947) and by Perley, Forbes and Pennoyer (1951). It was thought that some additional information might be obtained concerning the equilibrium level of Na^{24} if specimens of other body fluids could be examined at the same time as the blood plasma. The birth of a living, apparently healthy child with an incurable meningo-myelocoele offered an opportunity to determine the equilibrium level of the plasma and the cerebrospinal fluid.

The child, weighing 3·12 kg. (6 lb. 14 oz.), had an open myelocoele with the spinal cord and nerve trunks exposed. The opening through which the cerebrospinal fluid exuded was small, and during the experiment the opening was almost completely sealed with a pledget of vaseline gauze. As the child was incurable and was certain to die within a fortnight, the mother readily gave consent to the obtaining of multiple blood and cerebrospinal fluid samples.

Method

An injection of 25 microcuries of Na^{24} in a solution of isotonic NaCl, 3 ml., was injected into the external jugular vein. Using fresh syringes, specimens of blood and cerebrospinal fluid were withdrawn at intervals. The blood samples were collected in heparinized tubes, and later were centrifuged. Samples of plasma and cerebrospinal fluid, measured with a micropipette, were diluted to a total volume of 10 ml. These specimens were assayed for radioactivity in a G.M. M6 liquid counter (Veall, 1948). The results, corrected for radioactive decay, were plotted graphically, counts per minute per ml. as the ordinate, and time in hours after injection as the abscissa.

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Results

Equilibrium is attained between the blood plasma and the cerebrospinal fluid in four and a half hours. The shape of the plasma curve suggests that, although equilibrium is only attained then, the initial rapid diffusion involving transfer of the bulk of the Na^{24} to the extracellular spaces takes place in the first hour.

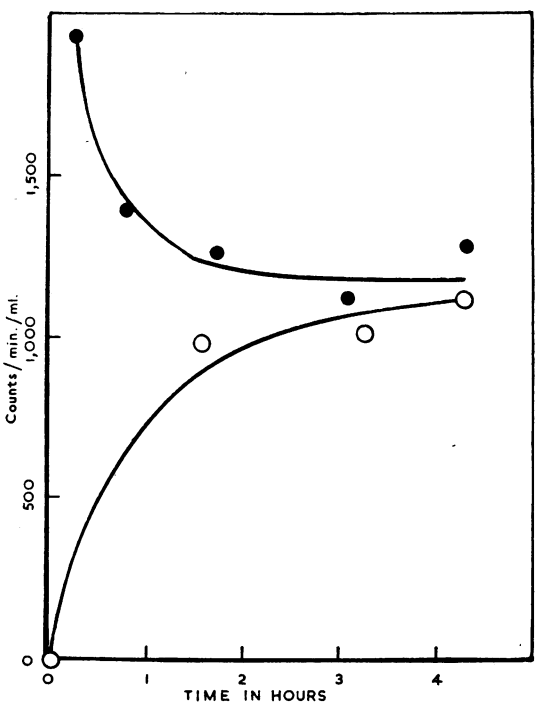

FIG. 1.—Graph showing the concentrations of Na^{24} in plasma and cerebrospinal fluid in a newborn infant with a myelocoele.

○ = Cerebrospinal fluid
● = Infant plasma

The ' sodium space ' is calculated as follows:

$$\text{'Sodium space' (ml.)} = \frac{\text{Total counts injected}}{\text{Counts/min./ml. plasma at equilibrium}}$$

The sodium space, expressed as a percentage of body weight, was 63·8.

Discussion

The value found, 63·8% of body weight, is higher than the values found by Flexner *et al.* (1947) and by Perley *et al.* (1951). The reason for this high value may be explained in this way. The myelocoele, although partly sealed off with a dressing, leaked a small quantity of cerebrospinal fluid. Over the first five days of infant life (the experiment was performed on the fifth day) if this leakage was 1 ml. per hour, approximately 120 ml. of fluid were lost. The quantity of cerebrospinal fluid produced when there is free drainage from the subarachnoid space is about 0·2 ml. per hour per kilogram body weight in dogs (Greenberg, Aird, Boelter, Campbell, Cohn and Murayama, 1943). A similar figure has been recorded in man (Masserman, 1934). This estimate of 1 ml. is therefore consistent. The sodium content of cerebrospinal fluid is from 3·0 to 3·4 mg. (Dailey, 1931). The sodium lost in this way was in the region of 380 mg. The total sodium in this infant (0·165% of 3·12 kg.) was less than 5 g. Thus about 7·6% of the infant's sodium was lost. The sodium ingested from milk was not sufficient to replace more than a part of this as at the most 150-225 mg. were received in 1,500 ml. of milk in the first five days of life (Mattice, 1941).

The sodium lost in the cerebrospinal fluid might be expected to be withdrawn from the bone reserves which store about 20% of the body sodium in the adult. The injection of 10 mg. of sodium (Na^{23} and Na^{24}) did not restore the adverse balance. The distribution of sodium in this case therefore was not strictly comparable with that occurring in a normal infant.

The infant remained healthy during the tracer study, but collapsed on the seventh day (two days afterwards) and died in a few hours. At necropsy there was no evidence of infection of the meninges, and no abnormality other than the malformation was found. The experimental findings, of partial sodium depletion, suggest that the disturbance of the electrolyte balance of the body may have been severe enough to be a contributing factor in the infant's death.

Summary

An injection of isotonic NaCl labelled with Na^{24} was given intravenously in an infant with a meningo-myelocoele.

Plasma and cerebrospinal fluid samples were obtained at intervals, and the concentrations of Na^{24} assayed.

The plasma and cerebrospinal fluid attained equilibrium in four and a half hours.

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