A CEREBROSPINAL FLUID BANK*

BY

HAROLD C. VORIS and PETER J. TALSO

From Mercy Hospital and the Stritch School of Medicine of Loyola University, Chicago, Illinois, U.S.A.

It has been found relatively simple to establish a cerebrospinal fluid bank. Spinal fluid removed at the time of pneumoencephalography may be preserved under sterile conditions by freezing and later used for replacement of cerebrospinal fluid lost at operation.

The importance of the composition of solutions used to irrigate the brain or replace lost cerebrospinal fluid has been known for a long time. Forty years ago, Flexner and Amoss (1917) showed that intraspinal injection of normal saline, Ringer's or Locke's solutions increased the susceptibility of monkeys to polio virus while the reinjection of spinal fluid from other animals did not regularly do so and the reinjection of autogenous spinal fluid never did. Weed and Wegeforth (1919) reported that irrigation of the subarachnoid space in cats with a modified Ringer's solution produced no apparent ill-effects while irrigation with normal saline produced severe disturbances, convulsions, states of acute mania, and often death. Kasahara (1924) studied the effect of different solutions on the spinal subarachnoid space of rabbits using the cerebrospinal fluid cell count as the criterion. He found that 0.6 to 0.7% sodium chloride solutions were less irritating than other concentrations of saline. Ringer's solution was less irritating than 0.7% saline and human cerebrospinal fluid was the least irritating of any substances used.

In 1934, Hartmann reported a method of preparing an artificial spinal fluid which Sachs (1945) used for replacement of spinal fluid lost from the ventricles at the time of operations for hydrocephalus. The preparation of this carefully buffered fluid required the preparation of two separate solutions which were separately sterilized and mixed just before using. Apparently the use of this fluid never became widespread, perhaps because of the technical difficulties of preparation.

Elliott and Jasper (1949) studied the effects of irrigating fluids on the pial blood vessels of cats. They described the preparation of two sterile solutions for irrigation of the brain during operation

and the replacement of fluid lost from the ventricles. One of these was a modified Ringer's solution, the other closely resembled Hartmann's solution but was more easily prepared. Lewis and Elliott (1950) later described the clinical use of this latter fluid, Solution B of Elliott and Jasper.

It occurred to one of us (H.C.V.) that human cerebrospinal fluid removed at routine pneumoencephalography might be kept sterile and preserved by freezing. An ample supply of such fluid would then be available for the replacement of fluid lost from the ventricles at operation and for the actual irrigation of exposed brain tissue during operation.

Initial studies were performed on specimens of human spinal fluid collected at the time of pneumoencephalography. These were frozen and stored for varying periods of time at -10°C . Chemical analyses of the spinal fluid were made at the time of collection and aliquots were then taken for analysis at monthly intervals during the period of storage. Sodium and potassium concentrations were determined with an internal-standard type flame photometer (Baird Associates), chloride by the method of Schales and Schales (1941), and pH with a Beckman pH meter. Total osmotic activity of the spinal fluid was determined by the measurement of the freezing point depression (Fiske Associates).

Table 1 summarizes the results obtained. In each case the first figures represent the values obtained at the time of initial analysis. Interim determinations performed at four-week intervals did not differ significantly. It will be noted that initially the values for the pH are higher than those usually observed in normal blood serum. This undoubtedly occurred because no precautions were taken to prevent the loss of carbon dioxide from the spinal fluid. On freezing and thawing the fluid at the time of later analyses the value for the pH rose further, probably because of a similar mechanism with further loss of carbon dioxide.

Technique

Since the chemical and physical characteristics of the fluid did not appear significantly altered by freezing and

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FIG. 1.—Photograph of apparatus used for collection of human cerebrospinal fluid. The plastic container for the fluid, the oxygen container, spinal puncture needle, four-way stopcock and connexions are shown. The 10 ml. Luer-Lok syringe is not shown.

prolonged storage, a cerebrospinal fluid bank has been developed for clinical use. Sterile plastic containers* of 300 ml. volume made originally for the collection and storage of citrated blood are used for the collection of the fluid (Fig. 1). Pneumoencephalography is carried out with the patient in the sitting position (Fig. 2). After lumbar puncture has been performed, the manometric pressure is determined. A specimen of fluid is taken for routine laboratory examination and culture. Unless the fluid is grossly clear, no effort to collect it is made. Specimens of fluid which become contaminated by blood during collection are discarded.

If it is decided to collect the cerebrospinal fluid for storage, a four-way Lundy stopcock shown in the diagram (Fig. 3) is attached to the lumbar puncture needle. A sterile connexion with a reservoir of O_2 gas is made. Another sterile connexion is made with the sterile plastic container and a fourth connexion with a sterile 10 ml. syringe. Now cerebrospinal fluid is withdrawn into the syringe in 5 to 10 ml. increments. These increments are injected into the storage container. Similar increments of O_2 are aspirated into the syringe and then injected into the spinal needle. The alternate aspiration of spinal fluid and injection of O_2 is carried out until the operator is satisfied that good visualization of the ventricles and subarachnoid spaces will be obtained radiologically. Usually 100 to 160 ml. of fluid is removed. The apparatus is then dismantled, the needle removed, and the patient taken to the x-ray department for the usual radiological examination.

FIG. 2.—Photograph of patient and equipment for the collection of cerebrospinal fluid at the time of pneumoencephalography.

*Fenwal Transfer Pack, catalogue number TA-2 manufactured by Fenwal Laboratories, Framingham, Massachusetts.

FIG. 3.—Cut-away diagram of Lundy four-way stopcock for the aspiration and collection of cerebrospinal fluid and the injection of oxygen. The 10 ml. Luer-Lok syringe is attached at (a). A Luer-Lok adaptor is used to connect the oxygen container to (b). Another Luer-Lok adaptor connects (d) to the plastic container for the cerebrospinal fluid. A short segment of rubber tubing with two Luer-Lok adaptors connects (c) to the spinal puncture needle. The direction of rotation of the stopcock is shown above the cut-away diagram for each position. Position 1 is used for the aspiration of fluid and the injection of oxygen. Position 2 permits the injection of fluid from the syringe into the plastic container. Position 3 allows aspiration of oxygen into the syringe.

TABLE 1
COMPOSITION AND BACTERIAL STATE OF SAMPLES OF C.S.F.

Specimen	Date	pH	Na—	K—	Cl—	Osmolarity (m.osm./litre)	Culture
			(m.Eq./litre)				
Bel	6/12/56	7.60	145	3.06	136	281	No growth
Bel	7/18/56	7.70	141	2.90	134	279	No growth
Gut	8/28/56	7.50	147	2.94	123	271	No growth
Gut	12/7/56	7.70	144	2.99	123	271	No growth
Ruf	4/9/57	7.54	146	2.90	122	270	No growth
Ruf	6/4/57	7.68	149	3.00	124	277	No growth

The container of cerebrospinal fluid is labelled and placed in the freezer at -20°C . If any abnormalities are found on laboratory examination of the fluid or if the culture shows bacterial growth, the collected fluid is discarded. Otherwise it is kept until it is needed for use. At that time the container is removed from the freezer and the fluid thawed at room temperature. It is then emptied into a sterile basin and warmed to 100°F . in a water-bath. A culture is taken before the fluid is used for irrigation or replacement. If such a culture should show bacterial growth, sensitivity studies would be made and appropriate therapy instituted. To date such a contingency has not been encountered.

The use of human cerebrospinal fluid in brain operations from a cerebrospinal fluid bank has proved practical. To date, there have been no complications. Human cerebrospinal fluid is

superior to artificial fluids. Wherever a tissue bank is in operation, the collection and preservation of the fluid is simpler than the preparation of complicated solutions, even one as simple as Solution A of Elliott and Jasper (1949). On most neurosurgical services, an ample supply of cerebrospinal fluid can be obtained from patients subjected to routine diagnostic pneumoencephalography.

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