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Cerebrospinal Fluid Electrolytes after Death. (23925)

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While isolated data on electrolytes in postmortem cerebrospinal fluid have been reported (1,3,5), a systematic study of the principal ions has not been available. The present report gives analyses of 157 postmortem cerebrospinal fluids and includes values for cations, anions and pH.

Materials and methods. The material consisted of 131 male bodies, average 57 years old, of white and colored race, autopsied on the average 10½ hours after death. A second series was used for pH determinations only and consisted of 26 cases, 62 years average age, examined after an average 5½ hour postmortem interval. To obtain data, which may be valid as "normals," cases were selected on the basis of pathological changes presumably unrelated to electrolyte metabolism. Cerebrospinal fluid was removed by cisternal puncture and, if free of gross contamination by blood or brain tissue, was used after centrifugation. The following analytical procedures were employed: flame photometry for sodium and potassium(4); Clark-Collip's method for calcium(2); Denis-Briggs' method for magnesium(2); Van Slyke-Hiller's modification of Sendroy's method for chlorides(2). The CO_2 values were previously published(5) and obtained by Van Slyke's gas volumetric method(2). Measurements of pH were performed at 37.5°C (within 60 min. after removal) with a Beckman pH meter and a blood electrode assembly provided with rubber cap, through which the spinal fluid was injected directly from syringe or after centrifugation under oil.

Results. Average and range of cations, anions and pH in postmortem cerebrospinal fluid 10½ and 5½ hours after death respectively are compiled in Table I and compared to corresponding antemortem values. It will be noted that there is a marked increase of potassium and inorganic phosphorus, a moderate increase of magnesium and a slight to moderate decrease of sodium, chlorides and HCO_3 after death, while calcium values approach closely those found during life. There is, however, more or less marked scattering of all values over wide ranges. The postmortem values of pH are considerably lower than antemortem figures.

The acid-base equilibrium in postmortem cerebrospinal fluid as seen in Table II shows fair agreement of the total milliequivalents of cations with the antemortem figure due to the fact that the sodium deficit is compensated by the potassium increase. On the other hand, there is a large deficit of 24 milliequivalents of anions due to the decrease of chlorides and HCO_3 ions in postmortem cerebrospinal fluid and insufficient compensation by the increase of phosphorus. This result causes an apparent shift of the acid-base equilibrium to the side of base.

Discussion. Mason, Klyne and Lennox(3) first observed the marked postmortem rise of cerebrospinal potassium, which however, failed to show close correlation with time after death except on a statistical basis. These findings were borne out by the present investigation, and here again a constant time relation was absent in regard to postmortem changes of sodium, chlorides and phosphorus. The increase of potassium and the decrease of sodium and chlorides are obviously due to autolytic changes of cell membranes with resultant greater permeability, so that intra-

TABLE I. Postmortem and Comparative Antemortem Values of Cerebrospinal Fluid Electrolytes (131 Cases) and pH (26 Cases).*

Electrolytes		Postmortem values: Avg	SD, % of avg	Postmortem values: Range	Antemortem values: Avg	Antemortem values: Range	Diff. in % of antemortem Avg
Na	mg %	292		247 –344	328	308 –352 (7)	
	meq/l	127	3.2	107 –150	143	134 –152 (7)	– 11
K	mg %	82		22 –157	11.8	9.8 – 14.3(7)	
	meq/l	21	6.1	5.6 – 40.0	2.9	2.5 – 3.7(7)	+610
Ca	mg %	4.8		3.8 – 6.8	5.0	4.5 – 5.2(8)	
	meq/l	2.4	6.2	1.9 – 3.4	2.5	2.3 – 2.6(8)	– 4
Mg	mg %	3.5		2.3 – 4.4	2.4	2.0 – 2.6(8)	
	meq/l	2.9	8.6	1.9 – 3.7	2.0	1.7 – 2.2(8)	+ 45
CO_2	vol %	21		10 – 58	59	57 – 62 (8)	
HCO_3	meq/l	9.4	3.3	4.5 – 26	26	25 – 28 (8,11)	– 64
Cl as NaCl	mg %	663		519 –833	730	697 –748 (10)	
as Cl	"	402		315 –505	444	423 –454 (10)	
"	meq/l	113	2.2	89 –142	125	119 –128 (10)	– 10
P (inorg.)	mg %	8.9		1.2 – 18.0	1.4	.9 – 2.0(6)	
	meq/l	5.2	5.6	.7 – 10.5	.8	.5 – 1.2(6,11)	+550
pH		6.38	.2	6.03– 6.95	—	7.35– 7.44(10)	

* For specified conditions see text.

cellular ions of higher concentration such as potassium may diffuse out into the extracellular fluid, and—vice versa—extracellular ions of higher concentration such as sodium and chlorides may diffuse into the cells. The increase of phosphorus, on the other hand, may be interpreted as evidence of postmortem esterase activity.

The stability of calcium in postmortem serum was noted by Hartl, Waldmann and Eder(1) and was presently confirmed also in postmortem cerebrospinal fluid. The moderate increase of magnesium may be explained similarly as that of potassium by diffusion from the cells, which contain a higher concentration of magnesium than extracellular fluid.

The apparent shift of the acid-base equilibrium to the side of base is in contrast with the actual acidity of postmortem cerebrospinal fluid as evidenced by the lowered pH values, which were observed recently also in postmortem blood by Straumfjord and Butler(9). This postmortem acidity is most likely caused by liberation of organic acid radicals, *e.g.* lactic acid, which presumably overcompensate the apparent shift to alkalinity.

TABLE II. Postmortem and Comparative Antemortem Acid-Base Equilibrium in Cerebrospinal Fluid (131 Cases).

Cations	Postmortem meq/l	Antemortem meq/l	Anions	Postmortem meq/l	Antemortem meq/l
Na	127	143	Cl	113	125
K	21	2.9	HCO_3	9.4	26
Ca	2.4	2.5	P	5.2	.8
Mg	2.9	2.0	S	1 *	1
Totals	153.3	150.4		128.6	152.8

* Normal antemortem value assumed in postmortem fluid.

Summary. (1) Cations and anions of postmortem cerebrospinal fluid have been studied in 131 cases, and pH determinations performed in an additional 26 cases. (2) Postmortem changes observed include marked increases of potassium and inorganic phosphorus, moderate increases of magnesium, slight to moderate decreases of sodium, chlorides and HCO_3 and a relative stability of calcium ions, the concentration of which approached closely antemortem values. (3) The acid-base equilibrium in postmortem cerebrospinal fluid was found shifted to the alkaline side by a deficit of anions in contrast to the actual acidity as determined by pH measurements, presumably due to liberation of organic acid radicals. (4) Postmortem electrolyte changes may be interpreted by greater permeability of cell membranes due to autolysis, while the increased inorganic phosphorus may result from postmortem esterase activity.

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Growth and CF Antigenicity of Measles Virus in Cells Deriving from Human Heart. (23926)

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Studies on virus susceptibility of cells deriving from adult human heart tissue indicated that measles virus attained comparatively high titers in such cultures(1). Availability of these preparations and the relative paucity of data on antigenicity of inactivated measles virus led us to employ complement-fixation (CF) as a method of antigenic investigation. The contributions of Enders and his group have included data on ability of tissue culture grown measles virus to serve as diagnostic CF antigen(2). Ruckle and Rogers(3) extended this approach to more fully characterize the antibody response. The material which follows amplifies these basic data.

Methods. A. *Tissue Culture*: Source of original tissue was a biopsy specimen from right atrial appendage of human heart removed during commisurotomy. Cultures were prepared by classic chick plasma clot method using minced tissue and basal medium (Eagle) containing 20% human serum. Growth of a fibrocytic type cell was observed after about 72 hours and became progressively extensive. Serial transfers to daughter cultures were performed after trypsinization of the sheet. After 4 months, the predominant cell type had become epithelial-like and has since propagated as such. *Tube cultures*, prepared by seeding about 70,000 cells/tube in 0.5 to 1 ml of above medium, were ready for use at 24 to 48 hours. Washed cultures were then maintained on medium containing 2 to 5% of either horse or chicken serum. 65% Scherer's MS and 30% Medium 199. The balanced salt solution portions of each of the synthetic media were according to the formula of Earle. *Virus*. Edmonston strain of measles virus was obtained from Dr. M. Reissig and had been through 23 human kidney passages, one HeLa cell passage and 4 passages in the Hep-2 cell. Production of initial pools of virus was performed by inoculation of tube cultures of heart cells. When cytopathic effects indicated that almost all cells had been infected (3 to 4 + degeneration), the cultures were frozen and thawed and supernatant fluid of lightly centrifuged preparations (TCF) reinoculated into fresh cultures. *Titrations* were performed by inoculating 2 to 4 culture tubes each with 0.1 ml of given virus dilution prepared in Hanks' BSS, and observing them for cytopathic effects daily for 14 days. Degeneration of fusiform or stellate type at dilution endpoint usually began by 8th day and progressed to completion by 12th to 14th day. *Complement-Fixation.* Crude tissue culture fluid antigens were prepared by inoculating flask cultures containing about 30,000,000 cells with large virus inocula (1 to 10 x 10^6 TCD_{50}). The basal medium in this instance was supplemented with 2% chicken serum.