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SERUM AND CEREBRAL SPINAL FLUID
CHEMISTRY VALUES FOR
THE MONKEY (MACACA MULATTA)

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ARMED FORCES RADIOBIOLOGY RESEARCH INSTITUTE
Defense Atomic Support Agency
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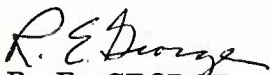
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SERUM AND CEREBRAL SPINAL FLUID CHEMISTRY VALUES
FOR THE MONKEY (MACACA MULLATA)

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FOREWORD
(Nontechnical summary)

At the Armed Forces Radiobiology Research Institute (AFRRI), chemical analyses of biological fluids of the monkey (Macaca mulatta) are being performed in a study to characterize injury produced by whole- or partial-body irradiation. Except for irradiation, control animals are subjected to the same manipulations as the experimental animals, i. e., prolonged confinement in restraining chairs. To determine the effect of the manipulations on the concentration of chemical parameters in serum and cerebral spinal fluid (CSF), base-line data were needed. A review of the literature failed to reveal adequate information on the base-line values of chemical components of the serum and CSF. While some data are available for serum constituents, the data required for the many parameters in the AFRRI study and data pertaining to sex or age differences are not available. This investigation was undertaken to establish base-line values for a wide spectrum of components in the serum and CSF of the young adult monkey.

Microanalytical procedures were applied to make possible a battery of measurements on a small volume of serum or CSF. Sodium, potassium, and calcium determinations were made using a flame photometer which records the intensity of colored light given off by these ions when they are excited by the heat of the flame. Chloride and lipase were measured using wet chemistry titrations. All other measurements were made using a spectrophotometer which analyzes, at a specific wavelength, the optical density of a substance in solution. (Optical density is a function of concentration of the chemical component.)

Normal values for the monkey were obtained for 24 different chemical components of serum and for 8 different chemical components of CSF. The values for serum were determined from 10 males and 10 females, 2 to 4 years of age. The serum concentrations for 8 of the 24 chemical components studied were found to differ significantly between sexes. Eight CSF parameters were determined on samples from 18 males and 12 females. Calcium, chloride, and total protein concentrations were found to be significantly different between sexes.

ABSTRACT

Normal values for 24 serum and 8 cerebral spinal fluid (CSF) chemical components were determined for the monkey (Macaca mulatta). Analyses were performed on serum from 10 males and 10 females, and sex-related differences in the levels of some of the constituents were evaluated. The serum levels of urea nitrogen, creatinine, allantoin, total protein, glutamic-pyruvic transaminase, lactic dehydrogenase, creatine phosphokinase, and amylase were significantly different between the sexes ($p < .05$). Chemical analyses were performed on CSF from 18 males and 12 females. Significant sex-related differences in concentration were found for calcium, chloride and total protein in CSF.

I. INTRODUCTION

In a research program employing a specific laboratory animal, data are often necessary on the animal in its normal physiologic state. At the Armed Forces Radiobiology Research Institute (AFRRI), chemical analyses of biological fluids of the monkey (Macaca mulatta) are being performed in a study to characterize injury produced by whole- or partial-body irradiation. A review of the literature failed to reveal adequate information on the chemical components of the serum and cerebral spinal fluid (CSF) of the monkey. While some data are available on normal values for some serum constituents,^{2, 4, 6, 7, 8, 16, 19} the data required for the many parameters in the AFRRI study are not available. This investigation was undertaken to establish base-line values for a wide spectrum of components in the serum and CSF of the monkey.

II. MATERIALS AND METHODS

Animals used in this study were "wild-caught" monkeys (Macaca mulatta) imported from the highlands of northern India.* The animals were 2 to 4 years of age as estimated by dentition.¹² They were conditioned, fed and housed as previously reported.^{17, 20}

The blood was withdrawn from a femoral vein through a 21-gauge 1-inch needle into a 10-ml syringe. CSF was collected from the cisterna magna using a 21-gauge 1-inch needle and a 5-ml syringe while the animal was under light anesthesia with Pentothal.† Each sample was immediately transferred to a clean glass test tube

* Asiatic Animal Imports, Inc., San Francisco, California

† Abbott Laboratories, Chicago, Illinois

after withdrawal. All samples were obtained between 8:00 a.m. and 9:00 a.m. from animals fasted for 16 hours.

The serum was separated from the clot approximately 45 minutes after blood withdrawal. Any sample (serum or CSF) exhibiting hemolysis was discarded. That portion of a sample not analyzed immediately was stored at -25°C up to 7 days. Serum or CSF stored in the frozen state was used only to analyze constituents stable under this condition as reported by Henry,¹¹ McKelvie et al.,¹⁵ and Frankel and Reitman.¹⁰

Serum chemical analyses were performed on samples from 10 male and 10 female monkeys. The CSF samples were collected from 18 male and 12 female monkeys. In most instances two CSF samples (2 ml per sample) were collected from each animal with an interval of 2 weeks between samples. Several parameters were duplicated to determine if a significant difference could be detected between samples taken at different times. All flame photometric procedures were carried out using a Beckman* flame photometer, Model 105. All spectrophotometric measurements were made using a Beckman* spectrophotometer, Model DU. The following techniques were employed:

Sodium and Potassium. Flame photometric method described by Annino,³ using a 1:200 dilution.

Calcium. (a) Flame photometric method described by Annino,³ using a 1:25 dilution; and (b) method of Ferro and Ham as described by Damm.⁹

Chloride. Mercuric nitrate titration as described by Annino.³

* Beckman Instruments, Inc., Fullerton, California

Inorganic Phosphorus. Fiske-SubbaRow method as described by Frankel and Reitman.¹⁰

Glucose. Hysel P-M-S procedure.¹⁴

Cholesterol. Liebermann-Burchardt reaction as described by Frankel and Reitman.^{10, 13}

Bilirubin. Modified Malloy-Evelyn technique as described by Annino.³

Urea Nitrogen. Gentzko-Masen method as described by Frankel and Reitman.¹⁰

Creatinine and Creatine. Methods as described by Frankel and Reitman.¹⁰

Allantoin. Method of Christman et al.⁵

Total Protein, Albumin, and Globulin. Reinhold method as described by Damm.⁹

Glutamic-Oxalacetic (GOT) and Glutamic-Pyruvic (GPT) Transaminases. Methods described by Amador and Wacker.¹

Total Lactic Dehydrogenase (LDH). Berger-Broida method as described by Frankel and Reitman.¹⁰

Aldolase. Method described by Amador and Wacker.¹

Creatine Phosphokinase (CPK). Method described by Amador and Wacker.¹

Amylase. Method as described by Somogyi.¹⁸

Lipase. Crandall and Cherry method as described by Annino.³

Phosphatases. Acid and alkaline phosphatases according to the p-nitrophenylphosphate procedure described by Frankel and Reitman.¹⁰

III. RESULTS

The monkey serum chemistry values, arranged according to sex, are summarized in Table I. Of the 24 serum components evaluated, 8 showed sex-related differences which were significant at the .05 level or lower.

Table I. Serum Chemistry Values for the Monkey (Macaca mulatta)*

Serum constituent	Units	Males†		Females†		p‡
		Mean ± S.E.‡	Range	Mean ± S.E.‡	Range	
Sodium	meq/liter	155.1 ± 0.6	152.0 - 157.0	154.0 ± 0.8	150.0 - 158.0	
Potassium	meq/liter	5.1 ± 0.1	4.5 - 5.8	5.1 ± 0.1	4.7 - 5.8	
Calcium**	meq/liter	5.3 ± 0.2	4.2 - 5.5	4.9 ± 0.2	3.8 - 5.8	
Calcium††	meq/liter	5.4 ± 0.1	5.0 - 5.8	5.4 ± 0.1	5.1 - 5.6	
Chloride	meq/liter	112.4 ± 0.8	110.0 - 118.0	114.2 ± 0.7	110.0 - 118.0	
Inorganic Phosphorus	mg/100 ml	5.8 ± 0.3	4.0 - 6.8	5.8 ± 0.3	4.5 - 6.8	
Glucose	mg/100 ml	102.0 ± 7.4	80.0 - 160.0	101.2 ± 7.2	68.0 - 135.0	
Cholesterol	mg/100 ml	175.5 ± 7.2	140.0 - 200.0	182.5 ± 8.9	140.0 - 240.0	
Bilirubin	mg/100 ml	0.19 ± 0.05	0.00 - 0.50	0.19 ± 0.04	0.00 - 0.40	
Urea Nitrogen	mg/100 ml	10.1 ± 0.9	7.0 - 15.0	12.8 ± 0.8	8.0 - 18.0	p < .02
Creatinine	mg/100 ml	1.50 ± 0.09	1.10 - 2.00	1.28 ± 0.06	0.95 - 1.65	p < .05
Creatine	mg/100 ml	0.05 ± 0.03	0.00 - 0.25	0.14 ± 0.05	0.00 - 0.40	
Allantoin	mg/100 ml	0.90 ± 0.11	0.55 - 1.65	1.29 ± 0.14	0.60 - 2.00	p < .02
Total Protein	g/100 ml	7.1 ± 0.1	6.6 - 7.8	7.4 ± 0.1	6.8 - 8.0	p < .05
Albumin	g/100 ml	4.2 ± 0.1	3.8 - 4.6	4.4 ± 0.1	3.9 - 5.2	
Globulin	g/100 ml	2.9 ± 0.2	2.0 - 3.8	3.0 ± 0.1	2.3 - 3.5	
Glutamiç-Oxalacetic Transaminase	Sigma-Frankel units/ml	37.6 ± 2.5	24.0 - 52.0	41.4 ± 3.2	24.0 - 60.0	
Glutamic-Pyruvic Transaminase	Sigma-Frankel units/ml	22.2 ± 1.1	18.0 - 29.0	31.4 ± 2.0	22.0 - 40.0	p < .01
Total Lactic Dehydrogenase	Berger-Broida units/ml	315.0 ± 19.8	200.0 - 680.0	496.0 ± 57.9	240.0 - 760.0	p < .01
Aldolase	Sibley-Lehninger units/ml	0	-	0	-	
Creatine Phosphokinase	Sigma units/ml	11.5 ± 1.4	6.5 - 17.1	6.3 ± 1.4	0.0 - 15.0	p < .01
Amylase	Somogyi units/100 ml	618.0 ± 25.0	514.0 - 720.0	490.0 ± 23.0	360.0 - 600.0	p < .01
Lipase	Sigma-Tietz units/ml	0.03 ± 0.01	0.00 - 0.10	0.04 ± 0.01	0.00 - 0.10	
Alkaline Phosphatase	Sigma units/ml	12.5 ± 1.7	4.8 - 20.4	10.0 ± 1.5	4.6 - 19.2	
Acid Phosphatase	Sigma units/ml	1.9 ± 0.2	1.2 - 2.9	2.0 ± 0.2	1.3 - 3.0	

* All monkeys were 2-4 years of age, and were fasted 16 hours prior to blood withdrawal.

† Each mean represents 10 animals.

‡ S.E. = Standard Error of the mean.

§ p = Probability that the two means are members of the same population, as determined by Student's t-test.

No value is listed for comparisons in which p > .05.

** Measured by spectrophotometry.

†† Measured by flame photometry.

All chemistry values for the CSF in the monkey are tabulated in Table II.

Samples taken at different times were not significantly different. Significant sex-related differences were found for three of the eight CSF components evaluated.

Table II. Cerebral Spinal Fluid (CSF) Values for the Monkey (Macaca mulatta)

CSF constituent	Units	Males			Females			p
		Number of samples	Mean \pm S.E.	Range	Number of samples	Mean \pm S.E.	Range	
Sodium	meq/liter	19	153.2 \pm 0.8	145.0 - 157.0	17	153.5 \pm 0.5	151.0 - 158.0	
Potassium	meq/liter	14	2.60 \pm 0.05	2.40 - 3.00	17	2.70 \pm 0.03	2.50 - 2.90	
Calcium*	meq/liter	20	2.30 \pm 0.02	2.20 - 2.50	17	2.50 \pm 0.02	2.40 - 2.70	p < .01
Chloride	meq/liter	24	131.8 \pm 0.4	129.0 - 134.0	20	133.5 \pm 0.4	131.0 - 137.0	p < .01
Total Protein	g/100 ml	24	41.7 \pm 0.9	35.0 - 50.0	20	37.5 \pm 1.0	31.0 - 47.0	p < .01
Glutamic-Oxalacetic Transaminase	Sigma-Frankel units/ml	24	21.0 \pm 0.7	15.0 - 29.0	20	19.5 \pm 0.5	16.0 - 24.0	
Glutamic-Pyruvic Transaminase	Sigma-Frankel units/ml	24	12.3 \pm 0.5	8.0 - 16.0	20	11.7 \pm 0.6	6.0 - 18.0	
Total Lactic Dehydrogenase	Berger-Broida units/ml	18	18.0 \pm 2.5	0.0 - 35.0	20	24.0 \pm 2.1	0.0 - 35.0	

* Measured by flame photometry

IV. DISCUSSION

Serum chemistry values in this study were generally in agreement with the results of other investigators.^{2, 4, 6, 7, 8, 16, 19} Where differences occurred they are thought to be due to variables such as analytical procedures, age, sex, or conditioning of the animals.

Factors considered in selecting serum chemical components for evaluation were: (a) availability of a rapid, accurate analytical method adaptable to small samples; (b) applicability to the detection of general tissue destruction, specific organ damage, altered metabolic processes, or other deviations from normal physiology in irradiation studies.

Differences in the concentrations of some serum chemical components were found between sexes; these components included urea nitrogen, creatinine, allantoin, total protein, glutamic-pyruvic transaminase, lactic dehydrogenase, creatine phosphokinase, and amylase. For the sample size studied these differences were significant; however the range of values for a given parameter was too great for the sex of an individual to be determined by evaluation of a serum specimen.

The CSF chemistry values were not in agreement with those reported by Anderson.² Analytical procedures differed in some cases between that study and the currently reported work. Although it is not clear if anesthesia was employed by Anderson, the current study was unable to detect a difference in CSF chemistry results between thiopental-anesthetized and unanesthetized animals. Differences between sexes were found for the CSF concentration of calcium, chloride, and total protein. No difference was found for five other components evaluated.

V. SUMMARY

Base-line serum and cerebral spinal fluid (CSF) chemistry values for the Macaca mulatta are presented. In blood serum, a significant difference between sexes was found for the concentration of urea nitrogen, creatinine, allantoin, total protein, glutamic-pyruvic transaminase, lactic dehydrogenase, creatine phosphokinase, and amylase. No significant sex-related differences were found for 16 other serum components. For CSF values, calcium, chloride, and total protein were found to be significantly different between sexes. No significant sex-related differences were found for five other components.

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13. ABSTRACT Normal values for 24 serum and 8 cerebral spinal fluid (CSF) chemical components were determined for the monkey (<u>Macaca mulatta</u>). Analyses were performed on serum from 10 males and 10 females, and sex-related differences in the levels of some of the constituents were evaluated. The serum levels of urea nitrogen, creatinine, allantoin, total protein, glutamic-pyruvic transaminase, lactic dehydrogenase, creatine phosphokinase, and amylase were significantly different between the sexes ($p < .05$). Chemical analyses were performed on CSF from 18 males and 12 females. Significant sex-related differences in concentration were found for calcium, chloride and total protein in CSF.		

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