

BIOCHEMISTRY OF THE NORMAL DURA MATER  
OF THE HUMAN BRAIN

DETERMINATION OF WATER, SODIUM, POTASSIUM, CALCIUM, PHOSPHORUS,  
MAGNESIUM, COPPER, IRON, SULFUR AND NITROGEN CONTENTS

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The studies on the chemical composition of the meninges are very scarce in the literature. The detailed handbook of Long, King and Sperry<sup>9</sup> has not the item on meninges, and the rare communications on the subject deal only with the concentrations of organic compounds and enzymes.

As a contribution to the knowledge on the inorganic constitution of these membranes, a study was carried out on the concentrations of water, sodium, potassium, calcium, phosphorus, magnesium, copper, iron, sulfur, and nitrogen in the dura mater of human subjects dead in consequence of craniocerebral trauma and showing no apparent disease of the brain or its envelopes.

MATERIAL AND METHODS

Specimens of dura mater weighing from 1.0312 to 2.0998 g were removed from 18 corpses with less than 24 hours of death due to craniocerebral trauma. Sixteen cases were male; 12 were white, 4 mulattoes and 2 negroes. Ages varied from 10 to 73 years, but the majority was in the 2nd, 3rd and 4th decades (Table 1).

The samples of dura mater were removed from the right or left half of the cranial vault; they had a normal aspect and contained no dural sinuses or hemorrhagic suffusions. The samples were immediately placed in a glass with a plastic cover and put in a freezer. Afterwards each sample was collected in a porcelain crucible and heated at 100°C for approximately 12 hr. until a constant weight was reached. The samples were ashed in a furnace overnight at 550°C. The ashes were dissolved in a known volume of 2N-HCl. In this solution sodium and potassium were determined by flame spectroscopy in a Coleman model 20; calcium

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Reg. No. *	Name	Age	Sex	Race
6980	J.A.S.	35	Male	Mulatto
7185	Unknown	± 25	Male	Mulatto
7186	C.M.F.	20	Male	Mulatto
7470	Unknown	± 35	Female	White
7471	Unknown	± 25	Male	White
7489	D.R.	55	Male	White
7498	W.R.C.	10	Male	White
7501	M.A.S.	21	Female	Negro
7502	J.B.B.	73	Male	White
7504	C.C.T.	20	Male	White
7505	L.P.	17	Male	Negro
7549	J.C.O.	29	Male	White
7550	M.M.	56	Male	White
7560	I.C.C.	29	Male	White
7584	D.E.V.	39	Male	White
7594	M.M.	39	Male	White
7595	L.M.	31	Male	White
7597	J.F.	49	Male	Mulatto

Table 1 — Identification of the 18 corpses: \* Medicolegal Institute number.

by the Clark and Collip<sup>2</sup> method; phosphorus by that of Fiske and Subbarow<sup>6</sup>; magnesium was determined by the yellow titan method (De Jorge, Silva and Cintra<sup>4</sup>); iron by Wong<sup>10</sup> method; nitrogen by that of Kjeldahl<sup>7</sup>. Copper was determined by the diethyldithiocarbamate method (De Jorge, Canelas and Costa-Silva<sup>3</sup>). All reagents were tested for copper contamination. The water used in all operations was redistilled in an all-glass distiller. The glassware used for analytical determinations was soaked overnight in chromic acid and washed thoroughly with redistilled water. The material was boiled in a 20% HCl solution for 2 hr, washed with redistilled water, and put in an oven to dry within a glass container. Sulfur was determined by the turbidimetric method described elsewhere (De Jorge, Silva and Cintra<sup>2</sup>; Canelas, De Jorge, Pereira and Sallum<sup>1</sup>).

The results were expressed in terms of dry weight: mequiv/100 g (K, Na, Mg), mg/100 g (Ca, P, S, Fe), g/100 g (N) and µg/100 g (Cu).

## RESULTS

The average concentrations of water, sodium, potassium, calcium, phosphorus, magnesium, copper, iron, sulfur and nitrogen in the normal dura mater are presented in Table 2.

## COMMENTS

Although varying between wide limits, the concentration of calcium in the normal human pachymeninx showed to be very high. This is in agreement with the results of Knoblic and Olsen<sup>8</sup>, who found calcified plaques of the spinal arachnoid membranes in 43.3 per cent of 217 non selected necropsies. The frequency of calcification grew with age. In our mate-

rial, however, no correlation was found between the Ca contents of the dura mater and age ( $r = 0.302$ ;  $t_r = 1.268$ ;  $0.3 > P > 0.2$ ).

We have not seen in the literature any reference to the concentrations of the other elements in normal human dura mater.

Element (and water)	No. of samples	Mean	$\pm$ Standard deviation
Water (g/100 g)	18	79.55	2.52
Sodium (mequiv/100 g)	18	1.63	0.27
Potassium (mequiv/100 g)	18	3.68	0.66
Calcium (mg/100 g)	18	119.84	107.40
Phosphorus (mg/100 g)	18	68.2	34.5
Magnesium (mequiv/100 g)	18	0.61	0.37
Copper ( $\mu$ g/100 g)	18	249.8	109.4
Iron (mg/100 g)	18	0.82	0.28
Sulfur (mg/100 g)	10	490.7	22.5
Nitrogen (g/100 g)	18	3.33	0.17

Table 2 — Results.

#### SUMMARY

The concentrations of water, sodium, potassium, calcium, phosphorus, magnesium, copper, iron, sulfur, and nitrogen were determined in samples of apparently normal dura mater removed from 18 subjects recently dead by craniocerebral trauma.

The average concentrations expressed in dry weight were: water 79.55 g/100 g  $\pm$  2.52; sodium 1.63 mequiv/100 g  $\pm$  0.27; potassium 3.68 mequiv/100 g  $\pm$  0.66; calcium 119.84 mg/100 g  $\pm$  107.40; phosphorus 68.2 mg/100 g  $\pm$  34.5; magnesium 0.61 mequiv/100 g  $\pm$  0.37; copper 249.8  $\mu$ g/100 g  $\pm$  109.4; iron 0.82 mg/100 g  $\pm$  0.28; sulfur 490.7 mg/100 g  $\pm$  22.5; nitrogen 3.33 g/100 g  $\pm$  0.17.

#### RESUMO

*Estudo bioquímico da dura mater normal do cérebro humano: conteúdo de água, sódio, potássio, cálcio, fósforo, magnésio, cobre ferro, enxofre e nitrogênio.*

Foram determinadas as concentrações de água, sódio, potássio, cálcio, fósforo, magnésio, cobre, ferro, enxofre e nitrogênio de espécimes de dura máter aparentemente normal retirados de 18 indivíduos recentemente falecidos em consequência de traumatismo crânio-encefálico.

As concentrações médias, expressas em peso seco, foram as seguintes: água 79,55 g/100 g  $\pm$  2,52; sódio 1,63 mequiv/100 g  $\pm$  0,27; potássio 3,68 mequiv/100 g  $\pm$  0,66; cálcio 119,84 mg/100 g  $\pm$  107,40; fósforo 68,2 mg/100 g  $\pm$  34,5; magnésio 0,61 mequiv/100 g  $\pm$  0,37; cobre 249,8

$\mu\text{g}/100 \pm 109,4$ ; ferro  $0,82 \text{ mg}/100 \text{ g} \pm 0,28$ ; enxôfre  $490,7 \text{ mg}/100 \text{ g} \pm 22,5$ ; nitrogênio  $3,33 \text{ g}/100 \text{ g} \pm 0,17$ .

#### REFERENCES

1. CANELAS, H. M.; De JORGE, F. B.; PEREIRA, W. C. & SALLUM, J. — Biochemistry of cerebral tumours: sodium, potassium, calcium, phosphorus, magnesium, copper, and sulphur contents of astrocytomata, medulloblastomata and glioblastomata multiforme. *J. Neurochem.* 15:1455-1463, 1968.
2. CLARK, E. P. & COLLIP, J. B. — A study of the Tisdall method for the determination of blood serum calcium with a suggested modification. *J. biol. Chem.* 63:461-464, 1925.
3. De JORGE, F. B., CANELAS, H. M. & COSTA-SILVA, A. — Contribuição ao estudo do metabolismo do cobre. Metodologia da determinação do cobre em materiais biológicos. *Rev. paul. Med.* 61:350-355, 1962.
4. De JORGE, F. B.; SILVA, A. G. & CINTRA, A. B. U. — Determinação quantitativa do magnésio nos materiais biológicos. *Rev. paul. Med.* 64:224-236, 1964.
5. De JORGE, F. B.; SILVA, A. G. & CINTRA, A. B. U. — Determinação quantitativa do enxôfre nos materiais biológicos. *Rev. bras. Med.* 21:491-494, 1964.
6. FISKE, C. H. & SUBBAROW, Y. — The colorimetric determination of phosphorus. *J. biol. Chem.* 66:375-400, 1925.
7. KJELDAHL, J. — Neue Methode zur Bestimmung des Stickstoffs in organischen Körpern. *Z. anal. Chem.* 22:366, 1883.
8. KNOBLICH, R. & OLSEN, B. S. — Calcified and ossified plaques of the spinal arachnoid membrane. *J. Neurosurg.* 25:275-279, 1966.
9. LONG, C.; KING, E. J. & SPERRY, W. M. — *Biochemist's Handbook*. Spon, London, 1961.
10. WONG, S. Y. — Colorimetric determination of iron and hemoglobin in blood. II. *J. biol. Chem.* 77:409-412, 1928.

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