DETERMINATION OF THE TIME OF DEATH BY ESTIMATION OF IONIC ACTIVITY

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A method of estimating activity of potassium, sodium, and hydrogen ions in the blood serum, vitreous humor, and cerebrospinal fluid (CSF) during the first 48 h after death has been developed in order to determine the time of death.

EXPERIMENTAL METHOD

Methods of obtaining biological media and of determining activity of sodium and hydrogen ions, together with the results of this investigation were described previously [1]. To determine potassium ion activity a potassium-selective valinomycin electrode was used. For this purpose 2.9 ml of a standard solution containing 1 mM KCl, 120 mM NaCl, and 5 mM Tris-HCl, pH 7.4, was poured into a cuvette. The course of the subsequent investigation was described previously [1]. Potassium ion activity was measured in 54 rabbits. The results were subjected to statistical analysis by a numerical method and, in addition, regression analysis was undertaken.

EXPERIMENTAL RESULTS

Immediately after death, the longer the time elapsing after death the higher the serum potassium ion concentration; this rule holds good until 36 h. Statistical analysis showed that differences between the values obtained were highly significant until 24 h ($P < 0.001$). Potassium ion activity in the CSF immediately after death lay within the range 10.60 ± 0.12 mM, but later until 24 h it fell rapidly to 47.40 ± 0.70 mM ($P < 0.001$ or $P < 0.05$); later it remained at almost the same level.

The rise of potassium ion activity in the vitreous humor followed a more uniform course than in the blood serum and CSF. The calculated criterion showed that at all time intervals the difference was statistically significant ($P < 0.001$ or $P < 0.01$).

The results of these investigations thus indicate a regular rise in potassium ion activity in the blood serum, CSF, and vitreous humor during the 48 h immediately after death (Table 1).

To increase the practical value of the results, a combined assessment of the activity of the three ions in each of the biological media of the cadaver was used. For this purpose a calculated coefficient (Q), reflecting the ratio of the product of the concentrations of sodium and hydrogen ions to the level of potassium ions, was used. Diagnostic regression equations were calculated in accordance with the results to study the blood serum, CSF, and vitreous humor (Table 2).

The equations obtained reflect the relationships illustrated in Fig. 1. Data calculated from the equations given in Table 2 show a significant fall in Q with an increase in the time after death.

On the basis of the results, working approximated graphs were plotted to determine the time of death (Fig. 2). For blood serum and CSF the coefficient Q can be seen to be signif-

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TABLE 1. Time Course of Potassium Ion Activity in Blood Serum, Vitreous Humor, and CSF Depending on Time of Death

Time after death, h	Blood			Vitreous humor			CSF		
	arithmetic mean value (aK^+), mM	standard deviation (S), mM	P	arithmetic mean value (aK^+), mM	standard deviation (S), mM	P	arithmetic mean value (aK^+), mM	standard deviation (S), mM	P
0	6,42	0,5	—	6,04	0,39	—	10,60	0,26	—
2	15,39	1,21	<0,001	7,72	0,52	<0,001	31,78	1,41	<0,001
4	20,45	1,12	<0,001	8,69	0,25	0,001<P<0,001	36,25	1,31	<0,001
6	26,73	1,22	<0,001	9,46	0,50	0,01<P<0,05	38,27	0,53	0,05<P<0,01
12	39,33	2,47	<0,001	10,76	0,37	<0,001	40,08	1,35	0,05<P<0,01
18	48,25	2,16	<0,001	12,00	0,45	<0,001	42,21	1,87	>0,05
24	53,79	1,59	<0,001	16,43	2,07	<0,001	47,40	1,56	<0,001
36	55,50	1,48	>0,05	20,29	1,81	0,01<P<0,05	47,19	1,22	>0,05
48	55,10	1,52	>0,05	30,22	2,64	<0,001	47,80	2,68	>0,05

TABLE 2. Approximation Equations for Curves Showing the Dependence of Q on Time of Death

Test object	Regression equation
Blood serum	$y=(8,82\pm0,35)+(134,5\pm2,78)\cdot 1/x$
Vitreous humor	$y=(141,42\pm0,25)-(3,35\pm0,02)\cdot x+ +0,03\cdot x^2$
CSF	$y=(15,83\pm0,23)+(39,38\pm0,67)\cdot 1/x$

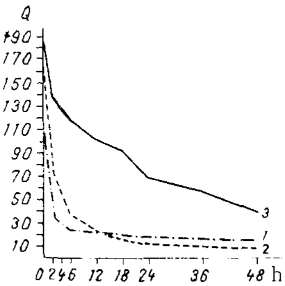

Fig. 1

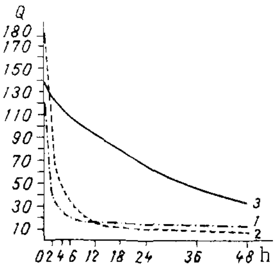

Fig. 2

Fig. 1. Graph showing dependence of coefficient Q on time of death: 1) blood serum, 2) CSF, 3) vitreous humor.

Fig. 2. Graph of approximated curves showing dependence of coefficient Q on time of death. Legend as to Fig. 1.

icant only for 4-6 h after death, and thereafter values measured in the vitreous must be used. Within the 6-12 h interval the accuracy of determination is ±1 h, and between 12 and 24 h it falls to ±3 h. The results obtained later still are not reliable. The accuracy of determination of the time of death on the basis of investigation of the vitreous humor is ±20 min until 6 h, ±40 min from 6 to 12 h, ±1 h from 12 to 24 h, ±3 h from 24 to 36 h, and ±4-10 h from 36 to 48 h after death.

To demonstrate the results described above an example from forensic practice will be given. It was necessary to determine the time of death of a man, H., aged 30 years, who died from mechanical injuries at the place of the accident. Investigation of blood from the right subclavian vein, CSF, and vitreous humor showed that the potassium ion activity in the blood serum was 25.41 mM, in the CSF 17.72 mM, and in the vitreous 10.01 mM. The corresponding values of the sodium ion concentration were 132.77, 136.04, and 140.22 mM, and of pH 6.83, 7.64, and 7.76. The coefficient Q was calculated and found to be 35.69 for blood, 63.07 for CSF, and 108.7 for the vitreous humor. By introducing coefficient Q into the corresponding equations from Table 2 the following times of death were established: according to blood serum 23 h 39 min (±1 h 50 min), to CSF 21 h 44 min (±2 h 53 min), and to vitreous 22 h 34 min (±30 min) before the investigation. The mean value for the three media was 22 h 29 min, and this was subsequently confirmed by the inquest.

Analysis of the results of the calculations shows that the suggested method of determining the time of death, on the basis of a combination of biological parameters and with the use of diagnostic regression equations, is accurate and reliable and can be recommended for appropriate trial in forensic medical practice.

LITERATURE CITED

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