TECHNICAL NOTE

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Biochemical Changes of the Synovial Liquid in Corpses with Regard to the Cause of Death. 1: Calcium, Inorganic Phosphorus, Glucose, Cholesterol, Urea Nitrogen, Uric Acid, Proteins, and Albumin

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ABSTRACT: We present in this work a study about biochemical changes of the synovial liquid in 100 corpses with regard to the cause of death. The results obtained in the different groups of causes of death show that the biochemical parameters were modified postmortem although we think that this modification is related more directly to the duration of the pathological process that leads to death than with the nature of the process itself.

KEYWORDS: pathology and biology, death, synovial liquid

The forensic doctor's first problem when he finds himself with the corpse of a subject that has no known pathology, and has therefore died unexpectedly without external signs of violence, is to establish the "cause of death." To do this in the necropsy operation he must look not only for explanatory signs of the origin of death, but also resort to those histological, biochemical, and histochemical complementary analyses that can give him as much information as possible to reach the most precise diagnosis.

Proof of this interest is the great number of authors who have endeavored to make this "physiology" and "pathology" of the corpse more well-known; among others we will quote Berg [*1*] who proposes to carry out biochemical tests and above all electrolyte studies, because as Castellano et al [*2*] comment, "their physiological figures are very constant and therefore any alterations can be detected postmortem." Coe [*3*] observes a hypernatremia and retention of urea in the blood in the clinical histories of mortal dehydration. Sturner et al [*4*] find decreases of chloride and sodium in the vitreous humor of children who have died from sudden death and of alcoholic subjects with fatty degeneration of the liver, as well as a decrease of calcium in severe trauma. Luna [*5*] refers to increase of lactic acid dehydrogenase (LDH) in the

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pericardial liquid of subjects who have died of pulmonary embolism, hemorrhages, or cranioencephalic trauma. Castellano et al [2] studied ions in serum noting that they do not vary in any of the groups of causes of death established by them. The proteins with regard to the cause of death have been studied by Lowrance and Donzelot (cited in Ref 6) and Sonnet et al (cited in Ref 7) in serum and they have found an increase of the alpha globulin in the serum of deaths caused by myocardial infarction. Luna [5] and Navarro et al [8] do not find variations of proteins in the pericardial liquid and the latter in serum finds a slight increase of the total proteins and the albumin in the deaths caused by asphyxia.

Materials and Methods

For our work we have used 100 samples of synovial liquid, coming from corpses of which 63 were men and 37 women, with ages between 14 and 93 years, and with two different origins:

(1) the first gorup of 53 liquids was obtained from the Forensic Anatomic Institute (Instituto Anatomico Forense) in Zaragoza and

(2) the second group of 47 liquids was obtained from the Hospital Clínico Universitario in Zaragoza.

These liquids have been grouped according to the cause of death of the subject in six groups:

Group 1: individuals who have died from cranioencephalic trauma and cerebral hemorrhages (24 cases).
Group 2: death from asphyxial-mechanisms (ten cases).
Group 3: death as a result of tumoral processes (18 cases).
Group 4: cardiac causes: mycardial infarction and cardiac insufficiency (19 cases).
Group 5: pulmonary causes: emboli, acute edema of the lung, and so forth (14 cases).
Group 6: miscellaneous, including: hepatic cirrhosis, comas, and so forth (15 cases).

We wish to point out that in none of the cases was the existence of articular pathology of any kind shown.

In these synovial liquids we have studied the biochemical parameters which we detail as follows: calcium, inorganic phosphorus, cholesterol, glucose, urea nitrogen, uric acid, proteins, and albumin, using for the analysis the apparatus Serum Multianalyzer Automatized 12/60, which uses chromometric methods.

The results obtained were submitted to a variance analysis (ANOVA) on one path. To check the equality of variances, Bartlett's test of homogeneity of variances was carried out. In those cases where this test showed an inequality, the transformation of the variable $\bar{x}$ in $\sqrt{\bar{x}}$ was done to stablize them and afterwards a second ANOVA was done.

Results and Discussion

The results obtained in the different groups of causes of death for calcium, inorganic phosphorus, and cholesterol showed significant differences after the mathematic treatment.

The studies of glucose, urea nitrogen, uric acid, proteins, and albumin did turn out to be significant and we will comment on them briefly.

Glucose

These results are shown in Table 1, where we see average figures which are significantly lower in the group of asphyxia (43.30 mg) and cardiac causes (24.45 mg) with regard to the mixed group (147.07 mg) and tumors (133.39 mg). Apart from this, in the limit of the significance, a decrease of the values of glucose is seen in the asphyxia on comparing them with the concen-

TABLE 1—*Glucose ANOVA after the transformation of the mean* $\bar{x}$ *into* $\sqrt{\bar{x}}$ *to stabilize the variance.*[a]

Cause of Death	Mean $\bar{x}$, mg/dL	$\sqrt{\bar{x}}$	Standard Deviation SD	No. of Cases
TCE	121.92	9.70	5.40	24
Asphyxia	43.30	6.10	2.61	10
Tumors	133.39	10.85	4.06	18
Cardiac	42.45	5.97	2.69	19
Pulmonary	111.20	9.43	4.91	14
Mixed	147.07	11.28	4.58	15

	INTERCLASS	INTRACLASS
Sum square $\sqrt{\bar{x}}$	412.74	1748.66
G.1	5	94
Variance	82.55	4.44

F.Snedecor = 4.44 Significant $P < 0.05$

[a]We have calculated the Newman-Keul's statistic to find between what groups of death causes there are significant differences. We have found differences between the mixed and tumor groups and asphyxia and cardiac groups.

tration of this parameter in subjects who have died from cranioencephalic trauma, hemorrhages (121.92 mg), or pulmonary causes (111.2 mg).

Tonge and Wannan [*9*] refer to a postmortem hyperglycemia in the myocardial infarction and asphyxial deaths that compare to the decrease of glucose which we found in the synovial liquid. We explain this because we have included the myocardial infarctions in a fuller group that we call "cardiac causes," which includes a very variable casuistry. The same occurs with the group of asphyxia.

Our result in the cranioencephalic trauma (TCE) group does coincide with that of Terbancea et al [*10*] who refer to hyperglycemia in the deaths caused by TCE; and hyperglycemia that they attribute to the destruction of structures of the central nervous system (CNS) which occurs as much as a result of trauma as of autolysis.

Commenting specifically on our results, we see higher figures of glucose in the tumor group and in the mixed group (comas, hepatic insufficiencies, and so forth), that is, in deaths which have been preceded by a prior agony period. During life as McCarthy [*11*] refers to, the cells of the articulations feed from the glucose which is filtered to the synovial liquid from the blood. We think that in the agony period this filtration continues, but the nutritious needs of the articular cells decrease, which would explain why the glucose figures are higher in the causes of death with slow evolution.

Urea Nitrogen

The results are shown in Table 2. The lowest values of this parameter are found in the group of subjects who have died from asphyxia (16.2 mg), and this concentration is significantly less than in the tumor group (63.83) and the mixed group (57.73). We think that this behavior can have the following interpretation. In a previous work [*12*] we see that the average figures of urea nitrogen were higher in the corpses whose death had been preceded by a long agony period. We ratify this finding here because, as we see, the urea nitrogen is increased in those deaths with slower evolution, that is, preceded by an agony period which responds to the general characteristics of Selye's general adaptation syndrome, with protein disintegration, increase of residual nitrogen, uremia, and uricemia.

TABLE 2—*Urea nitrogen ANOVA after the transformation of the mean* $\bar{x}$ *into* $\sqrt{\bar{x}}$ *to stabilize the variance.*[a]

Cause of Death	Mean $\bar{x}$, mg/dL	$\sqrt{\bar{x}}$	Standard Deviation SD	No. of Cases
TCE	34.38	5.01	3.03	24
Asphyxia	16.20	3.94	0.89	10
Tumors	63.83	7.48	2.88	18
Cardiac	30.69	4.88	2.69	19
Pulmonary	33.50	5.45	2.01	14
Mixed	57.73	6.68	3.75	15

	INTERCLASS	INTRACLASS
Sum square $\sqrt{\bar{x}}$	127.49	747.77
G.1	5	94
Variance	25.50	7.87
F.Snedecor = 3.24	Significant $P < 0.05$	

[a]We have calculated the Newman-Keul's statistic to find between what groups of death causes there are significant differences. We have found differences between the asphyxia group and tumor group.

Uric Acid

The results of this parameter with regard to the different causes of death are shown in Table 3.

The highest concentrations of uric acid are found in the subjects who died from mixed causes (10.06 mg), as well as those who had died from tumoral processes (9.28).

These two groups offer significant differences when they are compared with any of the other causes of death studied and those in the table we comment on and whose average figures are 5.85 mg for cranioencephalic trauma, 4.08 mg for asphyxia, 4.97 mg for cardiac causes, and 4.71 mg for deaths with pulmonary origin.

We interpret these differences of concentration of uric acid according to the cause of death, in the same way as we did for the urea nitrogen, that is, in the period of agony a protein degradation is produced with which nitrogenous compounds are freed. In this way the figures of said compounds increase when the agony is longer.

TABLE 3—*Uric acid ANOVA after the transformation of the mean* $\bar{x}$ *into* $\sqrt{\bar{x}}$ *to stabilize the variance.*[a]

Cause of Death	Mean $\bar{x}$, mg/dL	$\sqrt{\bar{x}}$	Standard Deviation SD	No. of Cases
TCE	5.85	2.29	0.79	24
Asphyxia	4.08	1.99	0.34	10
Tumors	9.28	2.97	0.68	18
Cardiac	4.97	2.13	0.67	19
Pulmonary	4.71	2.08	0.65	14
Mixed	10.06	3.04	0.95	15

	INTERCLASS	INTRACLASS
Sum square $\sqrt{\bar{x}}$	16.62	49.69
G.1	5	94
Variance	3.32	0.53
F.Snedecor = 6.29	Significant $P < 0.05$	

[a]We have calculated the Newman-Keul's statistic to find between what groups of death causes there are significant differences. We have found differences between the mixed group and TCE, cardiac, pulmonary, and asphyxia groups.

Total Proteins

The results obtained for the total proteins are shown in Table 4. The highest figures of total protein in synovial liquid appear in dead corpses as a result of cranioencephalic trauma (1.71 mg/dL) and asphyxia (1.68 mg/dL), whereas the lowest average corresponds to the tumor group (0.92 mg/dL).

These results agree with the argument that we adduced with regard to the protein nitrogenate by-products. Also, they correspond to the results which we showed in a previous work [*12*] for the total proteins when we compared the group of violent and natural deaths. In this case, it was also characteristic that in the group of violent deaths, the process was quicker and in general with no agony period, while the natural deaths were characterized by the majority being slow evolution processes.

TABLE 4—*Protein ANOVA after the transformation of the mean* $\bar{x}$ *into* $\sqrt{\bar{x}}$ *to stabilize the variance.*[a]

Cause of Death	Mean $\bar{x}$, mg/dL	$\sqrt{\bar{x}}$	Standard Deviation SD	No. of Cases
TCE	1.71	1.26	0.38	24
Asphyxia	1.68	1.27	0.28	10
Tumors	0.92	0.94	0.21	18
Cardiac	1.36	1.08	0.45	19
Pulmonary	1.54	1.19	0.37	14
Mixed	1.55	1.22	0.24	15

	INTERCLASS	INTRACLASS
Sum square $\sqrt{\bar{x}}$	1.41	10.97
G.1	5	94
Variance	0.28	0.12
F.Snedecor = 2.41	Significant $P < 0.05$	

[a]We have calculated the Newman-Keul's statistic to find between what groups of death causes there are significant differences. We have found differences between the tumor group with the asphyxia and TCE groups.

TABLE 5—*Albumin ANOVA after the transformation of the mean* $\bar{x}$ *into* $\sqrt{\bar{x}}$ *to stabilize the variance.*[a]

Cause of Death	Mean $\bar{x}$, mg/dL	$\sqrt{\bar{x}}$	Standard Deviation SD	No. of Cases
TCE	1.45	1.17	0.29	24
Asphyxia	1.34	1.14	0.23	10
Tumors	0.71	0.82	0.19	18
Cardiac	1.08	0.98	0.37	19
Pulmonary	1.10	1.02	0.26	14
Mixed	1.16	1.05	0.24	15

	INTERCLASS	INTRACLASS
Sum square $\sqrt{\bar{x}}$	1.45	7.27
G.1	5	94
Variance	0.29	0.08
F.Snedecor = 3.76	Significant $P < 0.05$	

[a]We have calculated the Newman-Keul's statistic to find between what groups of death causes there are significant differences. We have found differences between the tumor group with the TCE and asphyxia groups.

Albumin

The results obtained for albumin are shown in Table 5.

In it, we see for the total proteins that the highest values are those corresponding to the group of TCE (1.45 mg/dL) and asphyxia (1.34 mg/dL) and the lowest in the tumor one (0.71 mg/dL). We interpret these findings the same way as we did for the total proteins, that is, that in the agony period a protein degradation is produced.

Conclusion

As a summary of what we have just set forth we have to conclude that the behavior of these biochemical parameters is modified postmortem, although we think that this modification is related more directly to the duration of the pathological process that leads to death, than with the nature of the process itself.

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