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Postmortem Biochemical Changes in Canine Blood

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ABSTRACT: Antemortem and postmortem blood samples from 60 dogs were evaluated for sodium, chloride, potassium, urea nitrogen, glucose, creatinine, calcium, phosphorus, total protein, albumin, and carbon dioxide levels. Temperatures were 4, 20, and 37°C. Postmortem intervals were 3, 6, 12, 24, and 48 h. Blood urea nitrogen, calcium, and protein values remained stable after death, indicating diagnostic significance. Potassium, creatinine, and phosphorus levels increased with time and sodium, chloride, and total carbon dioxide levels decreased with time; therefore, determining these chemical values could be beneficial in estimating time of death. Glucose values were of limited value.

KEY WORDS: pathology and biology, blood, postmortem examinations

Before 1960 most studies of postmortem blood were concerned with sugar [*1-3*], nitrogenous compounds [*4-6*], and comprehensive chemistries [*7-11*]. Since 1960 additional work [*12-21*] has included studies on protein analysis [*17*], especially immunoglobulins [*18-21*].

This report is based on a study to determine the postmortem values for urea nitrogen, glucose, creatinine, sodium, potassium, chloride, calcium, phosphorus, total protein, albumin, and total carbon dioxide in dogs killed and held in an environmental chamber for 3, 6, 12, 24, or 48 h at 4, 20, or 37°C.

Materials and Methods

Experimental procedures were described previously [*22*].

Approximately 8 cm^3 of antemortem blood was removed from the right cephalic vein of each dog with a 19-gauge, 25-mm (1-in.) needle attached to a 12-cm^3 syringe. Postmortem blood was obtained by removing the right thoracic wall, opening the pericardial sac, and incising the right ventricle with a scalpel blade. Blood was removed with a 12-cm^3 syringe; this procedure was repeated on the left ventricle, although it was commonly empty.

Values were determined as previously stated [*23*]. Right and left heart values were combined because blood obtained from the left heart of dogs held at 20 and 37°C was insufficient to use for comparisons.

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Results

Chemical values of antemortem canine blood—along with means, ranges, standard deviations, and sample sizes—are given in Table 1. Postmortem values are given in Tables 2 to 12.

Stable Values

Values for urea nitrogen, calcium, total protein, and albumin were stable. All four chemistries remained stable for 48 h at 4°C, 12 h at 20°C, and 6 h at 37°C. The greatest antemortem-postmortem difference for blood urea nitrogen (BUN) was an increase of 2.5 mg/dl (Table 2). The greatest change for calcium was a drop of 2.45 mg/dl; however, several group means increased (Table 3). Total protein changed a maximum of 3.2 g/dl; albumin, 2.075 g/dl (Tables 4 and 5).

Increasing Values

Values for glucose, potassium, creatinine, and phosphorus increased. Glucose levels increased greatly in most of the groups, but dropped in two of them (Table 6).

TABLE 1—*Antemortem chemistries of canine blood.*

Constituent	Sample Size	Mean	Range	Standard Deviation
Chloride, meq/litre	60	112.32	97-122	4.18
Sodium, meq/litre	60	148.93	130-158	5.48
Potassium, meq/litre	60	4.22	3.1-6.2	0.48
Carbon dioxide, meq/litre	60	26.69	19-32	3.11
BUN, mg/dl	60	17.81	7-40	5.89
Total protein, g/dl	60	6.19	4.5-8.9	0.76
Albumin, g/dl	60	2.99	1.9-3.7	0.39
Calcium, mg/dl	60	9.79	7.9-11.6	0.67
Phosphorus, mg/dl	60	5.78	4-8.4	1.17
Glucose, mg/dl	60	105.35	63-140	17.62
Creatinine, mg/dl	60	0.79	0.3-1.2	0.16

TABLE 2—*Postmortem means (upper number), difference means (lower number) between postmortem and antemortem means, and sample size for urea nitrogen (mg/dl) in canine blood.*

	Postmortem Hours				
Temperature	4	6	12	24	48
4°C	12.975^{b*}	23.5^{a}	20.5^{ab}	13.5^{b}	22.87^{ab}
	$n = 4$	$n = 4$	$n = 4$	$n = 4$	$n = 4$
	0.725^{uvw**}	1.5^{uvw}	1.25^{uvw}	1.5^{uvw}	2.5^{vw}
20°C	15.25^{ab}	15.75^{ab}	21^{ab}	20^{ab}	...
	$n = 4$	$n = 4$	$n = 2$	$n = 2$	...
	0.5^{uv}	0.75^{uvw}	-0.5^{u}	3.5^{w}	...
37°C	18.5^{ab}	18.75^{ab}	23^{ab}	...	...
	$n = 4$	$n = 4$	$n = 1$	...	...
	0.75^{uvw}	-0.25^{u}	4^{w}	...	...

*Postmortem means with different superscripts are significantly different ($P < 0.05$).
**Difference means with different superscripts are significantly different ($P < 0.05$).

TABLE 3—*Postmortem means (upper number), difference means (lower number) between postmortem and antemortem means, and sample size for calcium (mg/dl) in canine blood.*

	Postmortem Hours				
Temperature	4	6	12	24	48
4°C	10.275^{a*}	10.475^{a}	9.825^{a}	7.85^{c}	9.3^{ab}
	$n = 4$	$n = 4$	$n = 4$	$n = 4$	$n = 4$
	0.7^{x**}	-0.4^{x}	0.025^{x}	-2.45^{y}	-0.425^{x}
20°C	9.775^{a}	9.875^{a}	9.45^{ab}	7.9^{bc}	...
	$n = 4$	$n = 4$	$n = 2$	$n = 2$	...
	0.625^{x}	0.175^{x}	-0.45^{x}	-1.15^{xy}	...
37°C	9.45^{ab}	9.375^{ab}	5.9^{d}	...	...
	$n = 4$	$n = 4$	$n = 1$	...	...
	-0.325^{x}	-0.9^{x}	-3.4^{y}	...	...

*Postmortem means with different superscripts are significantly different ($P < 0.05$).
**Difference means with different superscripts are significantly different ($P < 0.05$).

TABLE 4—*Postmortem means (upper number), difference means (lower number) between postmortem and antemortem means, and sample size for total protein content (g/dl) in canine blood.*

	Postmortem Hours				
Temperature	3	6	12	24	48
4°C	6.65^{b*}	7.175^{b}	7.05^{b}	9.25^{a}	7.8^{ab}
	$n = 4$	$n = 4$	$n = 4$	$n = 4$	$n = 3$
	0.65^{x**}	0.875^{x}	0.875^{x}	3.2^{y}	2.03^{xy}
20°C	6.825^{b}	7.725^{ab}	7.95^{ab}	8.4^{a}	...
	$n = 4$	$n = 4$	$n = 2$	$n = 1$	...
	0.525^{x}	1.425^{xy}	2.2^{xy}	3.9^{y}	...
37°C	7.15^{b}	7.225^{ab}	...	...	...
	$n = 4$	$n = 4$	...	...	...
	1.275^{x}	1.425^{xy}	...	...	...

*Postmortem means with different superscripts are significantly different ($P < 0.05$).
**Difference means with different superscripts are significantly different ($P < 0.05$).

TABLE 5—*Postmortem means (upper number), difference means (lower number) between postmortem and antemortem means, and sample size for albumin levels (g/dl) in canine blood.*

	Postmortem Hours				
Temperature	3	6	12	24	48
4°C	3.075^{bc*}	4.125^{abc}	4^{abc}	5^{a}	5.1^{a}
	$n = 4$	$n = 4$	$n = 4$	$n = 4$	$n = 4$
	0.275^{u**}	0.55^{uv}	1.05^{uvw}	1.975^{wx}	2.075^{wx}
20°C	2.75^{c}	3.85^{abc}	4.2^{abc}	4.6^{ab}	...
	$n = 4$	$n = 4$	$n = 2$	$n = 2$	...
	0.15^{u}	0.7^{uv}	1.15^{uvwx}	1.9^{vwx}	...
37°C	3.825^{abc}	3.425^{bc}	5.8^{a}	...	...
	$n = 4$	$n = 4$	$n = 1$	...	...
	0.55^{uv}	0.625^{uv}	3.2^{x}	...	...

*Postmortem means with different superscripts are significantly different ($P < 0.05$).
**Difference means with different superscripts are significantly different ($P < 0.05$).

TABLE 6—*Postmortem means (upper number), difference means (lower number) between postmortem and antemortem means, and sample size for glucose (mg/dl) in canine blood.*

	Postmortem Hours				
Temperature	3	6	12	24	48
4°C	139.25^{b*}	391.5^{a}	105.75^{b}	218^{ab}	171.75^{b}
	$n = 4$	$n = 4$	$n = 4$	$n = 4$	$n = 4$
	29^{x**}	276.75^{y}	-0.5^{x}	104.75^{xy}	65.5^{x}
20°C	217.75^{ab}	373^{a}	260.5^{ab}	121^{b}	...
	$n = 4$	$n = 4$	$n = 2$	$n = 2$	...
	106^{xy}	271.5^{y}	153^{xy}	25.5^{x}	...
37°C	130.25^{b}	201.5^{ab}	34^{b}	...	...
	$n = 4$	$n = 4$	$n = 1$	...	...
	39^{x}	84.75^{x}	-58^{x}	...	...

*Postmortem means with different superscripts are significantly different ($P < 0.05$).
**Difference means with different superscripts are significantly different ($P < 0.05$).

TABLE 7—*Postmortem means (upper number), difference means (lower number) between postmortem and antemortem means, and sample size for potassium (meq/litre) in canine blood.*

	Postmortem Hours				
Temperature	3	6	12	24	48
4°C	13.675^{f*}	25.475^{bcd}	24.1^{cd}	32.375^{ab}	33.125^{ab}
	$n = 4$	$n = 4$	$n = 4$	$n = 4$	$n = 4$
	9.475^{uv**}	21.125^{xy}	20.1^{xy}	27.85^{z}	28.975^{z}
20°C	11^{f}	10.8^{f}	31.5^{abc}	38^{a}	...
	$n = 2$	$n = 4$	$n = 2$	$n = 2$	...
	7.2^{uv}	5.875^{u}	27.6^{yz}	34.4^{z}	...
37°C	17.125^{ef}	21.75^{de}	36^{ab}	...	...
	$n = 4$	$n = 4$	$n = 1$	...	...
	12.825^{vw}	17.6^{wx}	30.8^{z}	...	...

*Postmortem means with different superscripts are significantly different ($P < 0.05$).
**Difference means with different superscripts are significantly different ($P < 0.05$).

TABLE 8—*Postmortem means (upper number), difference means (lower number) between postmortem and antemortem means, and sample size for phosphorus (mg/dl) in canine blood.*

	Postmortem Hours				
Temperature	3	6	12	24	48
4°C	15.925^{ab}	17.36^{ab}	19.125^{ab}	15.95^{ab}	25.125^{a}
	$n = 4$	$n = 3$	$n = 4$	$n = 4$	$n = 4$
	10.3^{xy**}	11.16^{xyz}	13.55^{xyz}	10.1^{xy}	18.625^{yz}
20°C	11.925^{b}	15.425^{ab}	24.2^{a}	27.5^{a}	...
	$n = 4$	$n = 4$	$n = 2$	$n = 2$	...
	7.225^{x}	10.1^{xy}	17.55^{xyz}	22.5^{z}	...
37°C	16.075^{ab}	19.925^{ab}	30.5^{a}	...	...
	$n = 4$	$n = 4$	$n = 1$	...	...
	10.15^{xy}	13.15^{xyz}	22.3^{yz}	...	...

*Postmortem means with different superscripts are significantly different ($P < 0.05$).
**Difference means with different superscripts are significantly different ($P < 0.05$).

TABLE 9—*Postmortem means (upper number), difference means (lower number) between postmortem and antemortem means, and sample size for creatinine (mg/dl) in canine blood.*

	Postmortem Hours				
Temperature	3	6	12	24	48
4°C	0.925^{c*}	1.1^{bc}	1.1875^{bc}	1.3875^{b}	1.35^{b}
	$n = 4$	$n = 4$	$n = 4$	$n = 4$	$n = 4$
	0.175^{u**}	0.375^{v}	0.4625^{vw}	0.7375^{xy}	0.575^{wx}
20°C	1.025^{bc}	1.125^{bc}	1.5^{b}	2.25^{a}	...
	$n = 4$	$n = 4$	$n = 2$	$n = 2$	...
	0.125^{u}	0.4^{vw}	0.75^{xy}	1.35^{z}	...
37°C	1.1125^{bc}	1.35^{b}	1.6^{b}	...	...
	$n = 4$	$n = 4$	$n = 1$	...	...
	0.2875^{uv}	0.575^{wx}	0.9^{y}	...	...

*Postmortem means with different superscripts are significantly different ($P < 0.05$).
**Difference means with different superscripts are significantly different ($P < 0.05$).

TABLE 10—*Postmortem means (upper number), difference means (lower number) between postmortem and antemortem means, and sample size for chloride (meq/litre) in canine blood.*

	Postmortem Hours				
Temperature	3	6	12	24	36
4°C	103.75^{ab*}	98^{bc}	93.25^{cd}	92.25^{cd}	85^{d}
	$n = 4$	$n = 4$	$n = 4$	$n = 4$	$n = 3$
	-7.25^{z**}	-15.75^{xy}	-19^{xy}	-22.75^{xy}	-28.3^{x}
20°C	108^{a}	95.5^{c}	92.5^{cd}	85^{d}	...
	$n = 4$	$n = 4$	$n = 2$	$n = 2$	...
	-6.25^{z}	-17^{xy}	-22^{xy}	-23.5^{xy}	...
37°C	99.25^{bc}	84^{d}	82^{d}	...	...
	$n = 4$	$n = 2$	$n = 1$	...	...
	-13.75^{yz}	-27^{x}	-29^{x}	...	...

*Postmortem means with different superscripts are significantly different ($P < 0.05$).
**Difference means with different superscripts are significantly different ($P < 0.05$).

TABLE 11—*Postmortem means (upper number), difference means (lower number) between postmortem and antemortem means, and sample size for sodium (meq/litre) in canine blood.*

	Postmortem Hours				
Temperature	3	6	12	24	36
4°C	143^{a*}	128.25^{cd}	131^{bc}	123.25^{cd}	127.25^{cd}
	$n = 4$	$n = 4$	$n = 4$	$n = 4$	$n = 4$
	-6^{yz**}	-9.75^{xyz}	-16.5^{wxy}	-31^{uv}	-19.75^{vwx}
20°C	145.5^{a}	138.25^{ab}	128.5^{bcd}	116.5^{de}	...
	$n = 4$	$n = 4$	$n = 2$	$n = 2$	...
	-0.25^{z}	-12.5^{wxyz}	-23.5^{uvwx}	-27.5^{uvw}	...
37°C	139.25^{ab}	125^{cd}	104^{e}	...	...
	$n = 4$	$n = 4$	$n = 1$	...	...
	-9.5^{xyz}	-27.25^{uvw}	-41^{u}	...	...

*Postmortem means with different superscripts are significantly different ($P < 0.05$).
**Difference means with different superscripts are significantly different ($P < 0.05$).

TABLE 12—*Postmortem means (upper number), difference means (lower number) between postmortem and antemortem means, and sample size for carbon dioxide (meq/litre) in canine blood.*

	Postmortem Hours				
Temperature	3	6	12	24	36
4°C	12.675^{a*}	5.45^{b}	7.15^{b}	3.5^{b}	3.125^{b}
	$n = 4$	$n = 4$	$n = 4$	$n = 4$	$n = 4$
	-14.325^{wxy**}	-21.175^{uvw}	-19.225^{vw}	-20.25^{uvw}	-25.25^{u}
20°C	16.25^{a}	7.25^{b}	3.5^{b}	3.5^{b}	...
	$n = 4$	$n = 4$	$n = 2$	$n = 2$	...
	-10^{y}	-18.5^{vw}	-24^{uv}	-18.5^{vwx}	...
37°C	14.125^{a}	5.5^{b}	4^{b}	...	...
	$n = 4$	$n = 4$	$n = 1$	...	...
	-11.875^{xy}	-23^{uv}	-22^{uvw}	...	...

*Postmortem means with different superscripts are significantly different ($P < 0.05$).
**Difference means with different superscripts are significantly different ($P < 0.05$).

Potassium, phosphorus, and creatinine were influenced by time and, to a lesser extent, by temperature (Tables 7 to 9). Although a rise in values could not be observed for all groups, the trend was apparent. Temperature had its greatest effect on values from 12 h on.

Decreasing Values

The chloride level dropped, without exception, for each time and for each temperature group (Table 10). The sodium level dropped for each time and temperature except in the blood of dogs held at 4°C for 24 h (Table 11). Values appeared stabler at 4°C than at 20 or 37°C. Total carbon dioxide values dropped, for all temperatures, to half of the antemortem value within the first 3 h and to a quarter by 6 h (Table 12). From 12 h on, decreases were considerably smaller.

Discussion

The postmortem BUN level in humans has been reported as remaining stable for 24 to 36 h [*5,10,12-15*]. We found values to be stable throughout a 48-h period in dogs held at 4°C. Stability dropped before 24 h for dogs held at 20°C and before 12 h for dogs held at 37°C. It is feasible that uremia can be diagnosed in the blood of refrigerated canine cadavers for quite some time.

The calcium level [*9,24*] in postmortem human blood reportedly is normal or elevated. In our study, calcium levels remained stable for the same times and temperatures mentioned for BUN. Apparently both hypercalcemia and hypocalcemia can be diagnosed in postmortem blood by considering time and temperature.

Naumann [*25*] and Coe [*17*] reported postmortem total protein levels in humans to be within the antemortem range. In our study, total protein and albumin levels remained stable, although they increased slightly with time. Because of the tendency of these values to rise rather than drop, antemortem hypoproteinemia can be detected in dogs.

Many researchers have reported postmortem glucose [*1-3,13,14,16*] values in humans. We question the diagnostic importance of postmortem glucose because the antemortem-postmortem difference in our study had a wide range, from a drop of 58 mg/dl to a rise of 276.75 mg/dl. Although postmortem glucose values are not beneficial for a diagnosis of hyperglycemia or hypoglycemia, high postmortem glucose levels in the early postmortem interval would eliminate a diagnosis of hypoglycemia.

Potassium, phosphorus, and creatinine values increased with time. After 12 h each temperature caused values to increase, but time had a greater influence. The increases in values were consistent and so could be used along with other criteria to establish the approximate time of death. Also, the levels could be used to evaluate other chemicals in animals whose time of death was unknown. For instance, determination of whether a high postmortem BUN is related to high antemortem levels or to postmortem change would be more accurate if phosphorus, potassium, and creatinine levels were determined to indicate the approximate time of death.

The creatinine level [*4-6,10,13,15*] in humans has been evaluated in determining renal disease. In this work, it increased with time and was less stable than urea nitrogen. However, determining creatinine level might be beneficial as an adjunct to diagnosing renal malfunction, as the degree of postmortem rise does not bring it into the range seen in uremia.

Postmortem sodium [*7,12*] and chloride [*7,12*] levels in humans have been reported as being lower than antemortem values. In our findings, time directly influenced the decrease in chloride and sodium values. Furthermore, increased temperature resulted in larger drops after 6 h. Since postmortem sodium and chloride levels dropped with increased time, they are an aid in determining the postmortem interval.

Jetter [*7*] stated that carbon dioxide content remained constant. Coe [*12*] found a decrease in content and considered it to be a technical artifact. In this study, total carbon dioxide content dropped to half of the antemortem value in the first 3 h and to a quarter in the first 6 h. After 6 h, the values were not significantly different. This finding is of value in approximating early times of death.

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