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Blood Gases and Acid–Base Status in Awake Dogs

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Summary. Forty-eight blood samples from twelve animals were obtained through a catheter in the femoral artery. Analysis yielded the following mean values; pH 7·37, $PaCO_2$ 35·9 mmHg, PaO_2 84 mmHg and base excess (BE) −3·5 mEq/l, haemoglobin 13 g/100 ml, heart rate 84/min, and arterial blood pressure 150/78 mmHg. These findings revealed a low blood bicarbonate with carbon dioxide content and a low pH relative to man. It is suggested that these observations should be taken into consideration in dogs being used for experimental research related to man.

Résumé. Quarante huit échantillons de sang sont obtenus par un catheter introduit dans l'artère femorable de douze chiens éveillés; les analyses ont donnès les valeurs moyennes suivantes; pH 7,37, $TaCO_2$ 35,9 mmHg, TaO_2 84 mmHg excès de bases 3,5 mEq/l, hémoglonine 13 g/100 ml, battements cardiaques 84/mm, tension arterille 150/70 mmHg. Ces paramètres montrent des valeurs moyennes de bicarbonate sanguin, de CO_2 et de pH qui sont plus bases que chez l'heme. Ces donnés deivent être prises en consideration chez les chiens soumis à une ventilation artificielle daus le domaine de la recherche.

Reports in the world literature on the arterial pH, PCO_2 and PO_2 in unanaesthetized experimental animals are very few (Dill *et al.*, 1932; Van Stewart *et al.*, 1966).

Previous study by Dill *et al.* (1932) demonstrated that the pH varied from 7·33 to 7·39 and averaged 7·38 and the arterial carbon dioxide (PCO_2) tension was 40 mmHg measured

TABLE 1. Acid-base status in conscious dogs from two investigators

Investigators	Temp. (△°C)	pH units	$PaCo_2$ (mmHg)	PaO_2 (mmHg)	Base excess (BE) (mEq/l)
Dill *et al.* (1932)	38·9	7·38	40	—	−3·6
Sodipo *et al.* (Present series)	37	7·37	35·9	84	−3·5

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TABLE 2. Data on acid–base changes in twelve awake dogs taken at half-hourly intervals for 2 hr

Dog no.	Sex	Weight (kg)	Date	Temp. (△°C)	pH Read	pH Corrected	$PaCO_2$ Read	$PaCO_2$ Corrected	PaO_2 Read	PaO_2 Corrected	Base excess (BE)	Hgb (g/100 ml)	Heart rate	Arterial blood pressure (mmHg)
1	♂	13·6	29.11.68	37	7·40	7·50	27	27	81	81	−6·6	13	72	90/55
			29.11.68	37	7·39	7·39	29	29	79	79	−6·1	13	80	110/65
			29.11.68	37·5	7·40	7·395	31·2	32	79	79	−4·3	13	80	125/75
			29.11.68	37·6	7·36	7·365	31·5	32·5	75	75	−6·5	13	78	95/60
2	♀	17·2	11.12.68	37·5	7·335	7·325	40	41	75	77·5	−4·2	13	100	125/55
			11.12.68	37·5	7·355	7·325	36	37	80	82·5	−6·5	13	100	135/80
			11.12.68	37·5	7·35	7·34	34	35	80·5	83	−5·3	13	96	145/75
			11.12.68	37·5	7·355	7·345	36·5	37·5	78·5	81·2	−5·0	13	92	145/90
3	♂	16·3	16.12.68	37	7·41	7·41	25	25	68	68	−7·1*	13	100	150/80
			16.12.68	37	7·40	7·40	28	28	68	68	−6·2	13	104	165/95
			16.12.68	37	7·41	7·41	28	28	69	69	−5·6	13	96	145/75
(Old dog)			16.12.68	37	7·415	7·415	27	27	72	72	−5·9	13	84	145/85
4	♂	15	17.12.68	37·8	7·38	7·38	41	42·7	90	94	−0·8	13	75	170/75
			17.12.68	37·0	7·41	7·41	38	38	86	86	−0·6	13	78	135/55
			17.12.68	37·8	7·40	7·385	37	38·5	79	83·5	−1·5	13	76	135/55
			17.12.68	37·8	7·39	7·37	40·5	43	81	88	0	13	72	140/75
5	♂	14	19.12.68	38·5	7·42	7·40	29	31	90	88	−4·3	13	96	140/75
			19.12.68	38·5	7·42	7·40	29	31	93	101	−4·3	13	90	145/90
			19.12.68	38.0	7·365	7.35	35·3	37	83	88	−4·5	13	75	150/80
			19.12.68	38·0	7·365	7·35	35	36·8	84	89	−4·6	13	72	150/80
6	♂	13·6	27.1.69	37·5	7·37	7·365	33	34	82	85	−5·4	15	80	125/70
			27.1.69	37·5	7·36	7·355	34·5	35·5	85	88	−5·5	15	88	120/70
			27.1.69	37·5	7·35	7·34	35·9	37	77	80	−5·0	15	96	125/70
			27.1.69	37·5	7·335	7·325	37	38	80	82·5	−5·3	15	100	120/65

7	♂	12·7	10.2.69	38·5	7·43	7·41	32	34	81	88	−2·1	13·5	80	185/110
			10.2.69	38·5	7·38	7·355	38	40·3	86	93	−2·3	13·5	96	175/90
			10.2.69	38·8	7·35	7·338	39	42·8	81	88	−3·0	13·5	100	175/70
			10.2.69	38·8	7·38	7·358	38	41·8	86	93	−2·0	13·5	100	145/80
8	♂	14·5	12·2·69	37·0	7·40	7·40	40	40	86	86	0	13·5	80	160/70
			12.2.69	37·5	7·385	7·375	34	35	75	78	−4	13·5	80	165/70
			12.2.69	38·0	7·40	7·385	33·5	35	80	85	−5	13·5	78	165/70
			12.2.69	38·8	7·38	7·385	38	41·5	86	93	−2	13·5	84	165/70
9	♂	15	7.5.69	38	7·365	7·35	36·0	37·8	81	86	−4·3	13	120	170/80
			7.5.79	38	7·365	7·35	37·0	38·5	82	87	−3·5	13	111	175/85
			7.5.69	37·5	7·35	7·34	35·9	37·0	77	80	−5·0	13	108	165/80
			7·5·69	37·5	7·335	7·325	37·0	38·0	80	82·5	−5·3	13	100	160/80
10	♂	14·5	9.5.69	37	7·42	7·42	27	27	80	80	−5·6	13	67	175/85
			9·5·69	37	7·38	7·38	29	29	76	76	−6·9	13	67	175/80
			9.5.69	37	7·405	7·405	28·9	28·9	74	74	−5·5	13	60	175/70
			9.5.69	37	7·405	7·405	27	27	79	79	−5·3	13	60	170/75
11	♂	13·1	3.7.69	39	7·39	7·36	37	38·5	83	93	−2	11	70	165/85
			3.7.69	39	7·39	7·36	36·5	38·2	70	79	−2·5	11	62	150/70
			3.7.69	39	7·375	7·349	37·5	40·5	68	72	−2·8	11	74	140/90
			3.7.69	39	7·40	7·37	36·5	37·9	67	75	−1·7	11	69	175/80
12	♂	13·6	11.7.69	37·5	7·41	7·405	28	28·5	90	93	−5·5	13	100	155/95
			11.7.69	37·5	7·40	7·395	29·5	30	90	93	−5·5	13	103	135/80
			11.7.69	38·0	7·35	7·338	39	42·8	81	88	−3·0	13	69	140/75
			11.7.69	38·0	7·365	7·35	35·3	37	83	88	−4·5	13	69	135/80

at 38·9°, but the arterial oxygen tension was not stated. The present study was undertaken to provide basic data on blood gases and acid–base status in awake dogs, awaiting experiments in the Anaesthesia Research Laboratory of the Faculty of Medicine, University of Toronto, Canada (Table 1).

MATERIALS AND METHODS

Twelve healthy mongrel dogs weighing 12·7–17·2 kg observed for 10 days before experiments, were used for the study. The animals were trained to lie quietly on a padded table and made accustomed to the laboratory surroundings and personnel before any experiment was attempted.

Blood was obtained from the femoral artery under anaerobic conditions by percutaneous puncture or by inlying polyethylene catheter. After a period of half an hour, blood samples were taken every 30 min from the femoral artery and analysed immediately at 37°C for pH, $PaCO_2$ and PaO_2 using a Radiometer (Copenhagen) Astrup micro-electrode operating through a model 22 pH meter. The arterial carbon dioxide ($PaCO_2$) and oxygen (PaO_2) tensions were measured using the original Saveringhaus double electrodes connected to a Radiometer pH electrode. The oxygen and carbon dioxide electrodes were calibrated using gas mixtures of known oxygen and carbon dioxide tensions.

In addition, arterial pH was measured using the micro-Astrup technique (1960) and the base excess (BE) was obtained from the Siggard-Anderson nomogram (Siggard-Anderson & Engel, 1960; Siggard-Anderson, 1962).

Femoral arterial pressure was measured with a Statham transducer (P23AA) connected to the polyethylene catheter and the heart rate was monitored by needle electrodes from limb leads connected to an electro-cardiogram. Both were recorded half-hourly on a six channel Beckman dynograph. Haemoglobin concentration of arterial blood was estimated by means of a Spencer haemoglobinometer.

RESULTS

The results of forty-eight measurements taken at half-hourly intervals in twelve conscious

TABLE 3. The range and mean values of acid–base balance, haemoglobin, heart rate, and blood pressure in twelve awake dogs

	Temp. Δ°C	pHa (units)	$PaCo_2$ (mmHg)	PaO_2 (mmHg)	Base excess (mEq/l)	Haemoglobin (g/100 ml)	Heart rate	Blood pressure (mmHg)
Range	37–39	7·325–7·415	25–43·3	68–108	0 to −7*	11–15	60–120	09/55–190/105
Mean	37·8	7·37	35·9	84	−3·5	13	84	150/38
SD±	—	±0·03	±5·1	±8·4	±1·72	—	—	—

* An old dog.
SD = Standard deviation.

dogs are shown in Table 2. Table 3 lists the ranges and mean values of temperature, pH, $PaCO_2$, PaO_2, base excess, haemoglobin concentration, heart rate and blood pressure.

The observed variations, corrected to 37°C, were in the arterial carbon dioxide tension (Table 2).

DISCUSSION

Table 3 shows that the acid–base status in normal conscious dogs correlates well with that of man apart from the lower arterial carbon dioxide tension in this series. Dill *et al.* (1932) reported average values of $PaCO_2$ 40 mmHg and pH 7·38 measured at a temperature of 38·9°C, and concluded that the $PaCO_2$ has the same value in dogs as in man, but the blood is slightly more acid.

The results from the present investigation (Table 1) indicate that a relatively low $PaCO_2$ of 35·9 mmHg and pH 7·37 are normal in our laboratory dogs. Probably the low arterial $PaCO_2$ reflects a smaller buffering capacity of the blood in these species. This fact harmonizes with the observation that the carbonic acid capacity in dogs is less than in man.

Dill *et al.* (1932) did not state the arterial $PaCO_2$. The result from our study suggests that unanaesthetized dogs have a mean PaO_2 of 84 mmHg which is within the normal limits obtained for man, although a little bit low. The relatively low value may be attributed to large number of arteriovenous shunts in the dogs (E. A. Elebute, personal communication). The base excess (BE) from the data of Dill *et al.* (1932) was −3·6 mEq/l, derived from carbon dioxide content of 21·4 mm/l (Table 3).

The base excess (BE) obtained from the present study was −3·5 mEq/l, which is similar to the data of Dill *et al.* (1932) (Table 3). This value suggests the occurrence of a non-respiratory acidosis, but the mechanisms underlying this 'metabolic' factor are not clear. The tendency for a lactic acidosis to develop in dogs in association with sympathetic stimulation and catecholamine release, as during ether anaesthesia (Brewster, Bunker & Beecher, 1952), suggests a similar mechanism during fear, fright and apprehension in conscious, unpremedicated dogs. This is supported in the present experiments by the persistence of low value for 'standard bicarbonate'. It should be noted that the only significant variation that occurs is in arterial PCO_2 and this is probably due to panting which is a normal physiological response in dogs. Haemoglobin value of 13 g/100 ml blood obtained in this investigation is similar to that in man.

The arterial blood pressure of 150/78 mmHg obtained in this study suggests a higher value for man of similar age, sex, height and weight. The heart rate of 84/min is also within normal limits for man.

Differences between the acid–base balance of the dog and man should be taken into account when interpreting results in this animal subjected to experimental research in relation to humans.

Ideally, the acid–base balance of the arterial blood should be standardized in all experimental studies in animal experiments.

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