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Comparative analysis of blood gas parameters from arterial, peripheral and central venous sites in dogs with renal dysfunction

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Abstract

Blood gas analysis is a part of point-of-care testing for patients presented with metabolic and respiratory emergencies. It is used for evaluating acid-base status and oxygenation indices in such patients. The objective of this study was to compare blood gas analytes obtained from different sampling sites like artery, central (jugular) vein and peripheral vein. This study was conducted prospectively on healthy normal dogs (n=7) and dogs with renal dysfunction (n=7) and data obtained was analyzed. Statistical non-significant difference ($p>0.05$) was recorded in pH, HCO_3 and BE in both normal dogs (n=7) and dogs with renal dysfunction (n=7), whereas pO_2 was observed to be significantly higher ($p<0.05$) in arterial blood samples when compared with jugular and peripheral venous samples. A strong correlation between arterial and peripheral venous pH (r=0.67), HCO_3(s) (r=0.77) and BE (r=0.78) could be demonstrated in dogs with renal dysfunction. As per the findings of this study, metabolic acid-base status represented by blood pH, HCO_3 and BE can be determined by peripheral venous sampling in dogs with renal dysfunction obviating need for arterial sample. The arterial sample, however is essential to determine oxygenation status of the patient.

Key words: Blood gas analysis, Arterial blood gas (ABG), Venous blood gas (VBG), Renal dysfunction.

Arterial blood gas analysis (ABG) is integral in critical care medicine to define acid base status of a patient. Arterial blood gas analysis provides information primarily about the pulmonary function, oxygenation and acid-base status of the patient. Despite its high efficacy in evaluating patient's status as well as its response to treatment regimens, ABG tests has some complications. Arterial puncture carries risk including arterial injury, hemorrhage, thrombosis and inadvertent hematoma formation and can be challenging to perform in routine clinical practice. (Razi *et al*., 2012). An alternative to arterial blood gas sampling is peripheral venous blood gas (VBG) sampling which is easier to perform. Analysis of venous blood gas provides global information on tissue perfusion and tissue acid-base balance (Day, 2002). Therefore VBG can be used as a diagnostic tool in analyzing metabolic acid-base disorders.

The differences between venous and arterial blood gas parameters have been investigated earlier by Ilkiw *et al*. (1991) and Wingfield *et al.* (1994) in normal dogs, dogs with metabolic acidosis, metabolic alkalosis and critically ill dogs. Gokel *et al.* (2000) opined, that a venous blood sample can be used to evaluate the acid-base status in uremic human patients. However relationship between ABG and VBG analytes in dogs with renal dysfunction has not been investigated. The objective of this study was to investigate the correlation between simultaneous ABG and VBG values, to determine whether venous blood gas parameters could correlate and whether it can potentially replace arterial blood gas analysis in dogs with renal dysfunction.

Materials and Methods

Blood gas analysis was done for healthy (normal) dogs (n=7) and dogs with renal dysfunction (n=7) with serum creatinine (>2.5mg/dl). Present study was initiated after permission from Institutional Ethics Committee for clinical research (Project Approval No: IAEC-VCR/Subcommittee/11/2018 Dated: 12/12/2018) of Mumbai Veterinary College, Mumbai.

Whole blood was collected from femoral artery, jugular vein (central vein) and saphenous vein (peripheral vein) simultaneously in 1 ml manually heparinized plastic syringes. The barrel of the syringe

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was coated with sodium heparin (Troyhep® 5000IU/5ml) and the excess heparin was forcefully expelled (Hopper and Epstein, 2012). The samples obtained from different sampling sites were transported on ice and processed within less than 20 minutes from the time of collection. Blood samples were analyzed on blood gas analyzer Eschweiler®. Machine was calibrated according to standard quality assurance protocols. All variables were measured and recorded at 37^0C. The machine used Ion Selective Electrode (ISE) principle for measuring the values.

Statistical analyses were conducted using commercial software WASP 2.0. Comparison between ABG and VBG values was done using CRD ANOVA and Pearson test of correlation. P-value <0.05 was considered statistically significant.

Results and Discussion

In the present study, the Mean ± SE for healthy normal dogs is represented in Table 1. The pO_2 (partial pressure of oxygen) was significantly higher ($p<0.05$) in arterial samples with Mean ± SE of 98.11 ± 3.29 mmHg when compared with jugular and saphenous venous samples. The pCO_2 (partial pressure of carbon dioxide) was significantly lower ($p<0.05$) in arterial samples with Mean ± SE 38.2 ± 1.62 mmHg when compared with jugular and saphenous venous samples. However, insignificant difference was recorded in pH, HCO_3(a) (Bicarbonate actual), HCO_3(s) (Bicarbonate standardized), BE (Base excess) and tCO_2 (total carbon dioxide content). Table 2 represents the results of correlation coefficients in blood gas analytes obtained from different sampling sites. Higher correlation coefficients were recorded in pH, HCO_3(a), HCO_3(s), BE and tCO_2 when samples form artery and peripheral vein were compared. The correlation coefficients for pH, HCO_3(a), HCO_3(s), BE and tCO_2 were high when arterial and jugular venous samples were compared.

The Mean ± SE for dogs with renal dysfunction is represented in table 3. Insignificant difference was recorded in values of pCO_2, pH, HCO_3(a), HCO_3(s), BE and tCO_2. Arterial pO_2 was significantly higher ($p<0.05$) than jugular and peripheral venous samples. The magnitude of correlation of coefficient between arterial, central vein and peripheral vein is represented in Table 4. A moderate degree of correlation between arterial and peripheral vein pH (r=0.67) and between arterial and central venous pH (r=0.60) was recorded. Strong degree of correlation (r=0.72) was recorded between arterial and peripheral venous pCO_2, while arterial and central venous pCO_2 recorded a moderate correlation(r=0.67). A strong correlation (r=0.78) and (r=0.85) was observed in values of HCO_3(a) from arterial and peripheral vein and arterial and central vein respectively. The correlation coefficients recorded for values of HCO_3(s) were (r=0.77) and (r=0.85) for arterial and peripheral vein and arterial and central vein respectively. A strong correlation was observed between arterial and peripheral venous BE (r=0.78) and arterial and central venous BE (r=0.86).

In the present study non-significant difference in the values of pH, HCO_3 and BE of healthy normal dogs and a strong correlation demonstrated by these parameters apprise the acid-base status from different sampling sites. These findings are consistent with Ilkiw *et al.* (1991) who reported that several venous sites (mixed venous, jugular venous and cephalic venous blood) accurately reflect the acid-base status of the

Table 1. Comparison between arterial, central venous and peripheral blood gas analytes in normal dogs (n=7)

Sr. no.	Blood Gas Analytes	Mean ± SE			Critical difference t(0.05)
		Femoral Artery	Jugular Vein	Saphenous Vein	
1	pO_2 (mmHg)	98.11^{a} ± 3.29	30.29^{b} ± 2.13	38.16^{b} ± 1.77	7.97
2	pCO_2 (mmHg)	38.21^{b} ± 1.62	45.64^{a} ± 0.76	42.87^{ab} ± 1.77	4.66
3	pH	7.45 ± 0.02	7.41 ± 0.02	7.41 ± 0.02	NS
4	HCO_3(a) (mmol/L)	25.49 ± 1.26	27.24 ± 1.41	26.83 ± 1.10	NS
5	HCO_3(s) (mmol/L)	26.11 ± 1.02	26.03 ± 1.20	25.89 ± 0.83	NS
6	BE (mmol/L)	1.41 ± 1.44	2.36 ± 1.70	2.11 ± 1.22	NS
7	t CO_2 (mmol/L)	26.43 ± 1.30	28.24 ± 1.52	27.91 ± 1.14	NS

Means with different superscripts vary significantly. ($P \leq 0.05$)
NS- Non-significant.

Table 2. Correlation between arterial and central venous, arterial and peripheral venous and central venous and peripheral venous blood gas analytes in normal dogs (n=7)

Sr. no.	Parameters	Arterial vs. Central vein	Arterial vs. Peripheral vein	Central vein vs. Peripheral vein
1	pO_2 (mmHg)	0.38	0.11	0.80
		NS	NS	(p<0.05)
2	pCO_2 (mmHg)	0.50	0.91	0.27
		NS	(p<0.05)	NS
3	pH	0.90	0.96	0.82
		(p<0.05)	(p<0.05)	(p<0.05)
4	HCO_3(a)(mmol/L)	0.97	0.84	0.83
		(p<0.05)	(p<0.05)	(p<0.05)
5	HCO_3(s)(mmol/L)	0.93	0.87	0.91
		(p<0.05)	(p<0.05)	(p<0.05)
6	BE (ecf) (mmol/L)	0.95	0.86	0.90
		(p<0.05)	(p<0.05)	(p<0.05)
7	tCO_2 (mmol/L)	0.97	0.83	0.85
		(p<0.05)	(p<0.05)	(p<0.05)

healthy conscious dogs. Significant correlations between central venous and arterial blood gas parameters were detected in B.E. (r=0.907) by Tamura *et al.* (2015). Our results reconfirmed that the B.E. between the central venous and arterial samples agreed in healthy normal dogs. Additionally, the other blood gas parameters (i.e. pH and HCO_3), also showed agreement between arterial, central venous and peripheral venous analytes. The variation in pO_2 and pCO_2 of arterial and venous blood is due to the physiological exchange of oxygen and carbon dioxide as blood flows through capillary bed of all tissues and capillary bed of alveoli of the lungs. The gaseous exchange in alveoli, delivering oxygen from lungs to the bloodstream and eliminating carbon dioxide ensues a high pO_2 and lower pCO_2 in arterial blood. On the other hand, jugular venous blood is lacking in oxygen and relatively rich in carbon dioxide due to the gaseous exchange that has occurred in the capillary bed of tissue cells (Higgins, 2011).

Platelet dysfunction and coagulopathy are commonly manifested by dogs with renal dysfunction (Bartges and Polzin, 2011). This predisposes these patients to ecchymosis or development of hematoma on arterial puncture (Shiroshita *et al*., 2000). Considering the risks involved in arterial puncture and challenges to perform in routine clinical practice, there is need to alternate arterial puncture with a venipuncture. A venous sample can easily be obtained in dogs and thus can be used as a substitute for arterial sample. Although Wingfield *et al.* (1994) recorded a higher correlation

Table 3. Comparison between arterial, central venous and peripheral blood gas analytes in dogs with renal dysfunction (n=7)

Sr. no.	Blood Gas Analytes	Mean ± SE			Critical difference t(0.05)
		Femoral Artery	Jugular Vein	Saphenous Vein	
1	pO_2 (mmHg)	98.17^a ± 5.13	33.11^b ± 3.46	47.37^b ± 6.66	16.85
2	pCO_2 (mmHg)	31.37 ± 1.91	42.29 ± 5.4	38.39 ± 3.84	NS
3	pH	7.29 ± 0.04	7.25 ± 0.02	7.29 ± 0.03	NS
4	HCO_3(a) (mmol/L)	15.26 ± 2.02	18.19 ± 2.58	18.63 ± 2.84	NS
5	HCO_3(s) (mmol/L)	17.03 ± 1.76	18.07 ± 1.79	18.93 ± 2.06	NS
6	BE (mmol/L)	-11.41 ± 2.6	-9.06 ± 2.76	-7.96 ± 3.21	NS
7	t CO_2 (mmol/L)	16.01 ± 2.07	19.26 ± 2.71	19.57 ± 2.93	NS

Means with different superscripts vary significantly. (P ≤ 0.05), NS- Non-significant.

Table 4. Correlation between arterial and central venous, arterial and peripheral venous and central venous and peripheral venous blood gas analytes in dogs with renal dysfunction (n=7)

Sr.no.	Parameters	Arterial vs. Central vein	Arterial vs. Peripheral vein	Central vein vs. Peripheral vein
1	pO_2 (mmHg)	0.15	0.57	0.79
		NS	NS	(p<0.05)
2	pCO_2 (mmHg)	0.67	0.72	0.99
		NS	NS	(p<0.05)
3	pH	0.6	0.67	0.71
		NS	NS	NS
4	HCO_3(a) (mmol/L)	0.85	0.78	0.97
		(p<0.05)	(p<0.05)	(p<0.05)
5	HCO_3(s) (mmol/L)	0.85	0.77	0.95
		(p<0.05)	(p<0.05)	(p<0.05)
6	BE (ecf) (mmol/L)	0.86	0.78	0.96
		(p<0.05)	(p<0.05)	(p<0.05)
7	tCO_2 (mmol/L)	0.84	0.78	0.97
		(p<0.05)	(p<0.05)	(p<0.05)

coefficient between arterial and central venous blood gas analytes in critically ill dogs, the etiology of the disease was not considered. In humans, venous pH and HCO_3 is a reliable indicator of arterial pH and HCO_3 in uremic patients (Gokel *et al*., 2000).

Conclusions

In conclusion, the present study recorded non-significant difference between arterial and peripheral venous samples of the dogs with renal dysfunction for all blood gas analytes except for pO_2. A strong correlation between arterial and peripheral venous pH (r=0.67), HCO_3(s) (r=0.77) and BE (r=0.78) demonstrated, thus obviates need for arterial sample and makes peripheral venous sample useful in assessing metabolic acid-base status in dogs with renal dysfunction.

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