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# State of Acid-base Balance in Dehydrated Camels (*Camelus dromedarius*)

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## ABSTRACT

There is a lack of information pertaining to the normal levels of acid-base parameters and the effects of dehydration on the acid-base balance in camels. The effect of water deprivation on acid-base balance was studied using five (2-years old) male dromedary camels. The camels were deprived of water for 7 days. Respiratory rate and blood gases were determined before the commencement and at the end of water deprivation period and during the first 48 h post rehydration. Blood pH did not differ significantly ($p = 0.14$) due to water deprivation in camels. However, respiratory rate was significantly ($p = 0.001$) elevated, while blood partial pressure of $CO_2$ ($pCO_2$), total $CO_2$ ($tCO_2$) and bicarbonate ($HCO_3^-$) were significantly ($p<0.1$) reduced in water deprived camels. This study demonstrates that although blood pH remains within normal range in water deprived camels, the primary challenge to water deprived camels is a mild respiratory alkalosis induced by reduced blood $pCO_2$ which may be the result of an accelerated respiratory rate.

**Key words:** Acid-base, blood gases, blood pH, camel, dehydration

## INTRODUCTION

Camel is a suitable desert animal that inhabits arid and semi-arid environments which are characterized by long periods of intense heat load and drought. Thermo-physiological mechanisms that enable camels to cope with water deprivation are well documented (Ayoub and Saleh, 1998; Al-Haidary, 2005, 2006; Abdoun *et al*., 2010). To our knowledge there is only one report (Yagil *et al*., 1975) on the impact of dehydration on acid-base status in camel. This report included only blood pH and $pCO_2$ as respiratory acid-base parameters. The vital limits of pH variation for mammals are between pH 7.36 and 7.44 (Houpt, 1989). Animal's body utilizes three basic mechanisms: Chemical buffering, respiratory adjustment of blood carbonic acid and excretion of $H^+$ or $HCO_3^-$ by the kidneys to combat any changes in the normal acid-base balance (Houpt, 1989). Water deprivation and dehydration are known to affect the concentration of plasma albumin (Al-Haidary, 2005) and blood hemoglobin concentration (Ayoub and Saleh, 1998) which could alter the blood buffering capacity. Further, dehydration affects renal function (Yagkil, 1993) and is associated with increased urine osmolality, reduced urine production and increased Na excretion (Ben Goumi *et al*., 1993). Moreover, dehydration is known to increase respiratory frequency and minute ventilation in camels (Schroter *et al*., 1987). It has also been reported that dehydration could result in changes of plasma cations and anions concentrations (Ayoub and Saleh, 1998;

Al-Haidary, 2005) which will be reflected on the alteration of Anionic Gap (AG). Anionic gap that contributes to the acid-base balance varies in response to changes in plasma concentrations of these components (Kirschbaum *et al.*, 1999). These effects of dehydration might have impact on the acid-base balance. Therefore, the intention of this study was to investigate whether camels could maintain their acid-base balance under prolonged water deprivation conditions.

## MATERIALS AND METHODS

Five (2-years old) clinically healthy male dromedary camels were purchased from the local market and transported to Experimental Farm Unit affiliated to Animal Production Department, College of Food and Agriculture Sciences, King Saud University, Riyadh. Camels were housed individually in shaded pens, fed at 2.5% of their body weight twice a day at 7:00 and 16:00 h on a commercial mix formulated pellets diet (ME 1950 kcal $kg^{-1}$, Crude protein 13%, Crude fat 2%, Crude fiber 10%, Ash 8% on DM basis) and had free access to clean tap water. During the experimental period water was with-held for 7 days.

Ambient temperature ($T_a$) was recorded continuously at 30 min interval using 2 data loggers (HOBO Pro Series data logger, Model H08-032-08, ONSET Co., USA) mounted at a height of approximately 2 m from the ground and placed away from direct sources of heat, sunlight and water. Special data logging software (BoxCar Pro 4, ONSET Co., USA) was applied for programming the loggers and for data analysis. The average daily ambient temperature ($T_a$) prevailed during the experimental period had a minimum value of 18.90±0.48°C and a maximum value of 39.21±0.75°C with an overall mean of 28.55±0.51°C.

Determination of the levels of blood acid-base parameters (blood pH, $pCO_2$, $pO_2$, $HCO_3^-$, $tCO_2$, BE, $O_2$ saturation) was carried on whole venous blood samples (~2.5 mL) collected by jugular venipuncture using heparin coated syringes (Terumo Co., Japan). Whole blood samples were analyzed within 1 h of collection using blood gas analyzer (Rapid System, Semense, USA). Respiratory rate was counted at the space from 9th to 11th rib using stethoscope (Littmann Stethoscope, USA) and expressed as breath $min^{-1}$.

**Statistical analysis:** Statistical analysis of the data was performed using the software program SigmaPlot Statistics (SigmaPlot 11.0, Systat Software, Inc., San Jose, CA, USA). The changes in respiratory rate and acid-base parameters which occur after experimental dehydration on the same individuals was tested using paired t-test to determine whether or not the treatment (water deprivation) had a significant effect. By concentrating on the changes produced by the treatment instead of the values observed before and after the treatment, paired t-test eliminate the differences due to individual reactions which gives a more sensitive (or more powerful) test for finding an effect. The overall level for statistical significance was set at $p<0.05$. All values were presented as means±standard error of the means (Means±SEM).

## RESULTS

**Acid-base parameters of camels:** During this study the blood acid-base parameters of dromedary camels was determined using venous blood samples collected from five adult apparently healthy camels. Table 1 shows the normal values of blood acid-base parameters of dromedary camel. Blood pH ranged from 7.28-7.44 with mean value of 7.35±0.03, $pCO_2$ ranged from 41.40-57.90 with mean

Table 1: Normal values of acid-base parameters in dromedary camels

| Acid-base parameters | Range | Mean±SE |
|---|---|---|
| pH (unit) | 7.28 - 7.44 | 7.35±0.03 |
| $pCO_2$ (mmHg) | 41.40-57.90 | 49.50±4.46 |
| $tCO_2$ (mmol $L^{-1}$) | 25.00-30.00 | 28.25±1.11 |
| $HCO_3^-$ (mmol $L^{-1}$) | 23.50-28.30 | 26.78±1.11 |
| BE (mEq $L^{-1}$) | -2.00-+4.00 | 1.25±1.25 |
| $pO_2$ (mmHg) | 23.00-26.00 | 24.25±0.63 |
| $O_2$ saturation (%) | 32.00-49.00 | 39.00±3.63 |

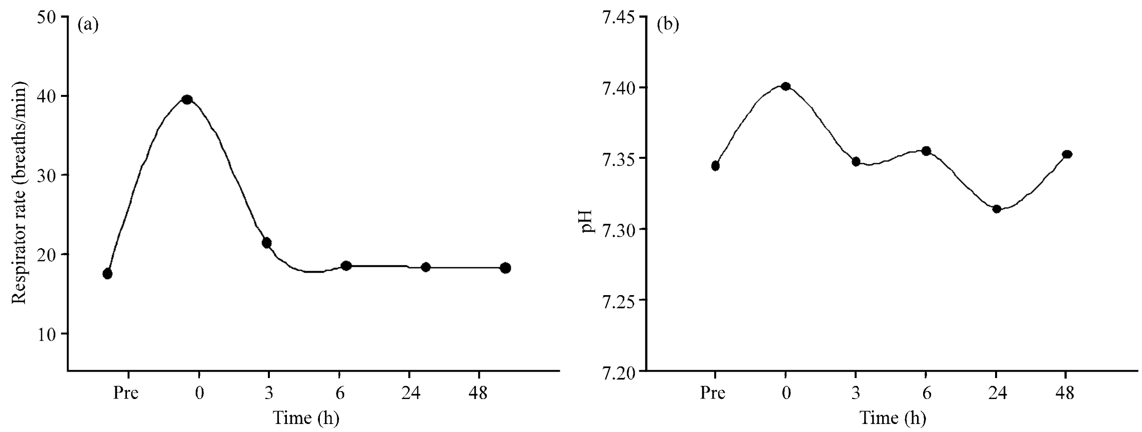


Fig. 1(a-b): Post rehydration recovery of (a) respiratory rate and (b) blood pH

value of 49.50±4.46 mmHg, $tCO_2$ ranged from 25.00-30.00 with mean value of 28.25±1.11 mmol $L^{-1}$, bicarbonate ion concentration ranged from 23.50-28.30 with mean value of 26.78±1.11 mmol $L^{-1}$, base excess ranged from -2.00-+4.00 with mean value of 1.25±1.25 mEq $L^{-1}$, $pO_2$ ranged from 23.00-26.00 with mean value of 24.25±0.63 mmHg and $O_2$ saturation ranged from 32.00-49.00 with mean value of 39.00±3.36%.

**Effects of dehydration on acid-base parameters:** Water deprivation for 7 days resulted in a significant ($p<0.01$) elevation of the Respiratory Rate (RR) from 17.66±0.13 to 39.36±1.85 breath/min which is reflected in a significant ($p<0.1$) reduction of blood partial pressure of $CO_2$ ($pCO_2$) from 49.50±4.46 to 41.25±1.51 mmHg, blood total $CO_2$ ($tCO_2$) from 28.25±1.11 to 27.00±1.08 mmol $L^{-1}$ and blood bicarbonate ($HCO_3^-$) concentration from 26.78±1.11 to 25.63±1.14 mmol $L^{-1}$. While, Base Excess (BE) was insignificantly reduced from 1.25±1.25 to 0.50±1.32 mEq $L^{-1}$. These resulted in a slight insignificant increase, albeit within the physiological range of blood pH from 7.35±0.03 to 7.40±0.01. Dehydration also resulted in a slight insignificant elevation of blood partial pressure of $O_2$ ($pO_2$) from 24.25±0.63 to 25.75±2.10 mmHg and that of $O_2$ saturation from 39.00±3.63 to 46.25±5.25% (Table 2).

**Post rehydration recovery of acid-base parameters:** Rehydration of camels resulted in a fast recovery of respiratory rate (from 39.36±1.85 breath/min) and blood pH (from 7.40±0.01) to the pre-dehydration levels (18.71±0.26 breath/min and 7.35±0.03, respectively) within 3 to 6 hours post rehydration (Fig. 1). However, other acid-base parameters ($pCO_2$, $tCO_2$, $HCO_3^-$, BE, $pO_2$ and $O_2$ saturation) did not completely recover to pre-dehydration levels till 48 h post rehydration (Fig. 2a-f).

Table 2: Effects of dehydration on Respiratory Rate (RR) and acid-base parameters in dromedary camels (Means±SE)

| | Euhydrated | Dehydrated | p-value |
|---|---|---|---|
| RR (breath/min) | 17.66±0.13 | 39.36±1.85 | 0.001 |
| pH (unit) | 7.35±0.03 | 7.40±0.01 | 0.14 |
| $pCO_2$ (mmHg) | 49.50±4.46 | 41.25±1.51 | 0.07 |
| $tCO_2$ (mmol $L^{-1}$) | 28.25±1.11 | 27.00±1.08 | 0.02 |
| $HCO_3^-$ (mmol $L^{-1}$) | 26.78±1.11 | 25.63±1.14 | 0.03 |
| BE (mEq $L^{-1}$) | 1.25±1.25 | 0.50±1.32 | 0.32 |
| $pO_2$ (mmHg) | 24.25±0.63 | 25.75±2.10 | 0.56 |
| $O_2$ saturation (%) | 39.00±3.63 | 46.25±5.25 | 0.32 |

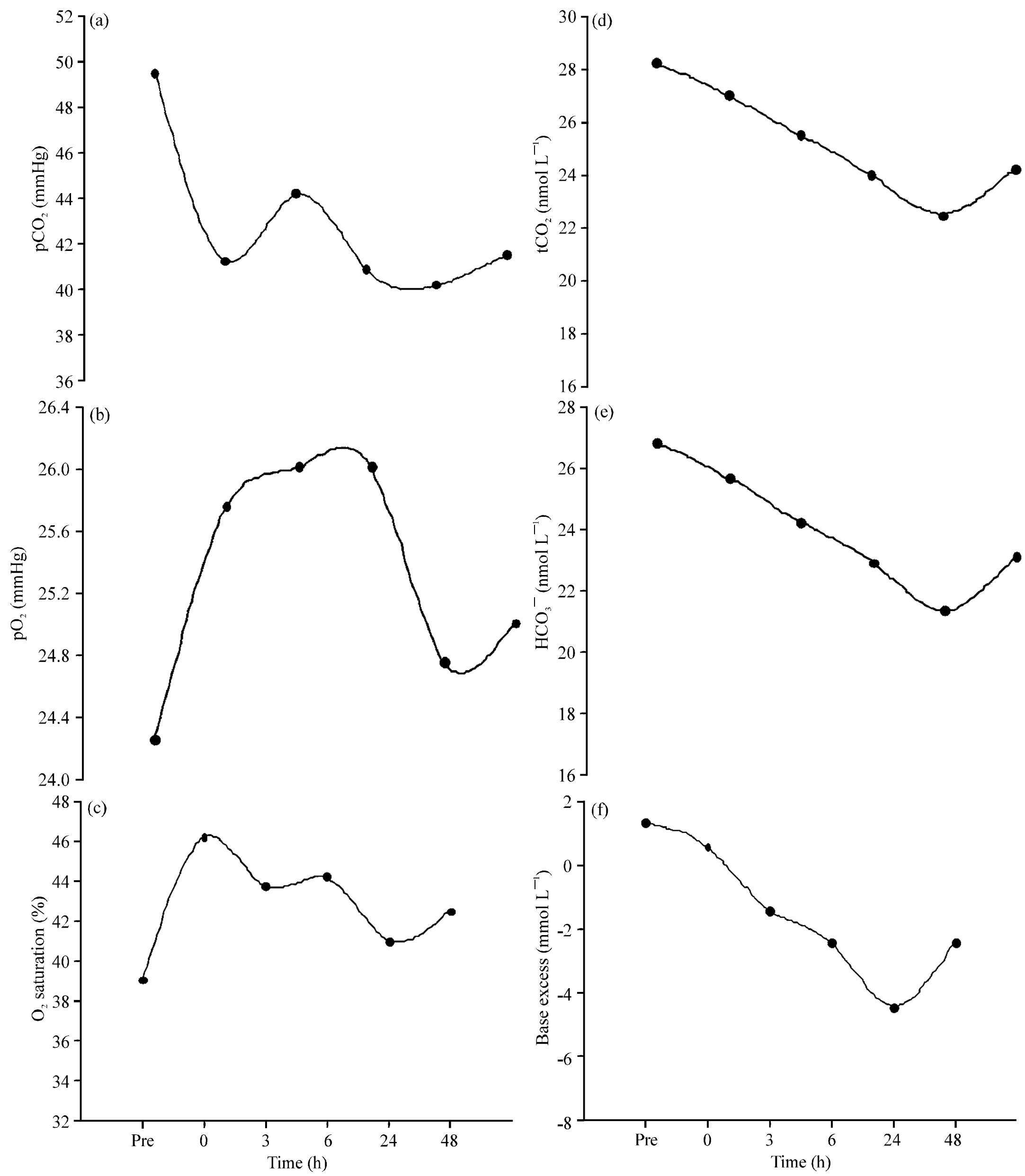


Fig. 2(a-f): Post rehydration recovery of (a) $pCO_2$, (b) $pO_2$, (c) $O_2$ saturation, (d) $tCO_2$, (e) $HCO_3^-$ and (f) BE

## DISCUSSION

Knowledge of the acid-base status of camels is important for evaluating the physiological and health status of this species. Apart from isolated references to blood pH, $pCO_2$ and Stewart variables (Yagil *et al.*, 1975; Elkhair and Hartmann, 2010) little is known about acid-base status in camels. Blood acid-base parameters of camels are reported for the first time in this study. The blood acid-base parameters of camels reported in this study were revealed using venous blood. It has been reported that venous blood samples are in most cases sufficient for the evaluation of uncomplicated acid-base disorders (Meintjes and Engelbrecht, 1995). The reported levels of blood acid-base parameters in camels differ from that reported in arterial blood of cows (Piccione *et al.*, 2004), venous blood of steers (Parker *et al.*, 2003) and venous blood of sheep (Srikandakumar *et al.*, 2003; Sobiech *et al.*, 2005). However, similar to that reported in venous blood of white-tailed deer (DelGiudice *et al.*, 1994).

Since the increase in body core temperature is known to stimulate both minute ventilation and respiratory rate (Schroter *et al.*, 1987, 1989). The observed water deprivation induced significant ($p = 0.001$) increase in respiratory rate of camels could be a reflection of the dehydration induced elevation of body core temperature (Al-Haidary, 2005). Precise regulation of blood acid-base balance is vital because the activities of almost all enzyme systems in the body are influenced by the $H^+$ concentration (Fraser, 1991). Although water deprivation tended to elevate blood pH ($p = 0.14$) in dromedary camels, the increase is within the normal range reported in this study (Table 1). However, water deprivation caused a tendency towards respiratory alkalosis and is most probably due to hyperventilation and the subsequent significant ($p = 0.07$) decrease in $pCO_2$ due to increased elimination of $CO_2$ (Table 2). The $CO_2$ eliminated is derived from carbonic acid ($H_2CO_3$) which dissociates to form $CO_2$ and $H_2O$. The $HCO_3^-$ is converted to $H_2CO_3$ by receiving $H^+$ from the buffer systems, such as hemoglobin, plasma proteins and extra cellular fluid phosphates which resulted in the observed significant ($p = 0.03$) reduction of $HCO_3^-$ concentration. During respiratory alkalosis, a decrease in plasma $HCO_3^-$ would be expected. Where, the body tries to compensate for the respiratory alkalosis by excreting $HCO_3^-$ through the kidneys and retaining $H^+$ ions. This could be supported by the reported elevation of aldosterone concentration in the blood of water deprived camels (Abdoun *et al.*, 2010) which is known to stimulate $H^+$ secretion by intercalated cells in the collecting duct, regulating plasma bicarbonate ($HCO_3^-$) levels and its acid/base balance (Rector and Brenner, 2004). To support respiratory alkalosis, urine samples should have been collected for urine pH analysis.

Physiological systems attempt to maintain homeostasis so that BE (the deviation of buffer base of blood from the normal value) remains near zero. In this study Base Excess (BE) was maintained near zero after 7 days of water deprivation. Venous blood $pO_2$ and $O_2$ saturation tended to increase due to water deprivation. This could be the result of the reported reduction in feed intake and metabolic rate in water deprived camels (Fowler, 2010). Although, respiratory rate and blood pH returned to control values within 3 h of rehydration, respiratory acid-base parameters did not completely return to control values during 48 h post rehydration.

## CONCLUSION

The results reported in this study identified reference values of acid-base parameters that can be used for the clinical diagnosis of acid-base disturbances in camels. Further, when dromedary camels were subjected to water deprivation, they were still able to maintain a normal acid-base balance despite the significant acceleration of their respiratory rate.

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## REFERENCES

Abdoun, K., A. Alameen, W. Elmagbol, T. Makkawi and A. Al-Haidary, 2010. Effects of hydration status on osmolality and minerals profile of serum and forestomach liquor in dromedary camel (*Camelus dromedaries*). J. Camel Pract. Res., 17: 235-240.

Al-Haidary, A., 2006. Seasonal variation in thermoregulatory and some physiological responses of Arabian camel (*Camelus dromedaries*). J. Saudi Soc. Agric. Sci., 5: 30-41.

Al-Haidary, A.A., 2005. Effect of dehydration on core body temperature of young Arabian camels (*Camelus dromedaries*). J. King Saud Univ. Agric. Sci., 18: 1-7.

Ayoub, M.A. and A.A. Saleh, 1998. A comparative physiological study between camels and goats during water deprivation. Proceedings of the 3rd Annual Meeting for Animal Production under Arid Conditions, May 2-3, 1998, UAE University, Al-Ain, UAE, pp: 71-78.

Ben Goumi, M., F. Riad, J. Giry, F. de la Farge, A. Safwate, M.J. Davicco and P. Barlet, 1993. Hormonal control of water and sodium in plasma and urine of camels during dehydration and rehydration. Gen. Comp. Endocrinol., 3: 378-386.

DelGiudice, G.D., L.D. Mech and U.S. Seal, 1994. Nutritional restriction and acid-base balance in white-tailed deer. J. Wildlife Dis., 30: 247-253.

Elkhair, N.M. and H. Hartmann, 2010. Studies on acid-base status (Stewart's model) of young camels (*Camelus dromedarius*) after acid-load with $NH_4Cl$. Berliner und Munchener Tierarztliche Wochenschrift, 123: 153-159.

Fowler, M.E., 2010. Medicine and Surgery of Camelids. 3rd Edn., Wiley-Blackwell, USA., ISBN-13: 978-0813806167, Pages: 636.

Fraser, C.M., 1991. The Merck Veterinary Manual: A Handbook of Diagnosis, Therapy and Disease Prevention and Control for the Veterinarian. 7th Edn., Merck and Co. Inc., Rahway, NJ., USA., ISBN-13: 9780911910551, Pages: 1832.

Houpt, T.R., 1989. Water, Electolytes and Acid Base Balance. In: Dukes Physiology of Domestic Animals, Swenson, M.J. (Ed.). 10th Edn. Cornell University Press, Ithaca, New York, USA., pp: 486-506.

Kirschbaum, B., D. Sica and F.P. Anderson, 1999. Urine electrolytes and the urine anion and osmolar gaps. J. Lab. Clin. Med., 133: 597-604.

Meintjes, R.A. and H. Engelbrecht, 1995. The role of the large intestine in acid-base balance in sheep. S. Afr. J. Sci., 91: 352-354.

Parker, A.J., G.P. Hamlin, C.J. Coleman and L.A. Fitzpatrick, 2003. Quantitative analysis of acid-base balance in *Bos indicus* steers subjected to transportation for long duration. J. Anim. Sci., 81: 1434-1439.

Piccione, G., G. Caola and J.P. Mortola, 2004. Day/night pattern of arterial blood gases in the cow. Respir. Physiol. Neurobiol., 140: 33-41.

Rector, F.C. and B.M. Brenner, 2004. Brenner and Rector's the Kidney. 9th Edn., Saunders, Philadelphia, PA., USA.

Schroter, R.C., D. Robertshaw, M.A. Baker, V.H. Shoemaker, R. Holmes and K. Schmidt-Nielsen, 1987. Respiration in heat stressed camels. Respir. Physiol., 70: 97-112.

Schroter, R.C., D. Robertshaw and R.Z. Filali, 1989. Brain cooling and respiratory heat exchange in camels during rest and exercise. Respir. Physiol., 78: 95-105.

Sobiech, P., A. Stopyra, Z. Kuleta, M. Zbanyszek and S. Milewski, 2005. Acid-base balance parameters of arterial, venous and capillary blood in sheep. Bull. Vet. Inst. Pulawy, 49: 125-127.

Srikandakumar, A., E.H. Johnson and O. Mahgoub, 2003. Effects on heat stress on respiratory rate, rectal temperature and blood chemistry in Omani and Australian merino sheep. Small Ruminant Res., 49: 193-198.

Yagil, R., Z. Etzion and G.M. Berlyne, 1975. Acid-base parameters in the dehydrated camel. J. Vet. Med., 100: 1105-1108.

Yagkil, R., 1993. Renal function and water metabolism in the dromedary. Contrib. Nephrol., 102: 161-170.