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Changes in Acid-base Balance, Blood Gases and Hemato-biochemical Parameters in Arabian Camels with Different Urinary Tract Disorders

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ABSTRACT

The current study was planned to document the status of acid-base status and blood gases in camels with urinary tract disorders together with the hemato-biochemical parameters. Twenty-nine camels with urinary disorders were examined. Urinary disorders included cystitis, urine retention, hydronephrosis, red urine, renal masses, ruptured bladder and ruptured urethra. Fifteen healthy camels were used as controls. Compared to a value of 7.54±0.16 in healthy camels, the blood pH in camels with urinary disorders was 7.30±0.15. The HCO_3 level has decreased in diseased versus control camels. However, the PCO_2 was higher in camels with urinary disorders compared to healthy ones. The PO_2 in this study was lower in camels with urinary disorders than healthy animals. However, the TCO_2 was higher in diseased than healthy camels. In contrast, the SO_2 was decreased in diseased camels compared to healthy controls. Lactate concentration did not differ significantly between diseased camels and controls. Neutrophilic leukocytosis and lymphopenia were the remarkable hematological changes in diseased camels when compared to healthy controls. In comparison to healthy controls, the serum concentration of albumin was highly significantly decreased in camels with urinary diseases compared to controls. In contrast, the globulin concentration was significantly high in camels with diseased animals compared to controls. Other remarkable findings included increased serum concentration of blood urea nitrogen (BUN), creatinine and glucose. In conclusion, in comparison to values in the healthy camels, the blood pH, HCO_3, PO_2 and O_2 are lower in camels with urinary disorders; however, the PCO_2 and TCO_2 were higher in the diseased camels versus healthy animals. Additional outstanding results in diseased camels include neutrophilic leukocytosis, hypoalbuminemia, hyperglobulinemia, hyperglycemia, and increased concentrations of BUN and creatinine.

Key words: Animals, Animal health, Diseases, Pathophysiology, Physiology.

INTRODUCTION

In a slaughterhouse survey, various renal disorders affecting camels were reported. It included pigmentation of the renal capsule, hyperemia of the medulla, calcification of the sub-capsular region, discoloration of the renal cortex and medulla, renal pelvis hemorrhage, kidney stones and hydatidosis (Kojouri et al. 2014). Renal lesions included in a second study vascular congestion, bleeding, hydronephrosis, nephritis, amyloidosis and nephrosis (Saini et al. 2015). In Saudi Arabia, different renal lesions in camels were detected at slaughterhouse (Barakat et al. 2017). In the later report, microscopic changes included shrinkage and hyalinization of the glomeruli, congestion of the cortex and medulla, swelling of the tubular cells, interstitial hemorrhage and glomerular tufts thickening (Barakat et al. 2017). Different urinary tract disorders were reported in dromedary camels that included cystitis, urine retention, hydronephrosis, nephrolithiasis, hydronephrosis, pyelonephritis, renal abscessations, pigmented urine, renal masses, ruptured bladder, ruptured urethra and renal neoplasia (Tharwat and Al-Sobayil 2016; Tharwat 2020a; Tharwat 2021a; Almundarij and Tharwat 2023).

Conservation of proper acid-base status is vital for almost all physiological procedures happening within the living organism body (Quade et al. 2021). In Arabian camels, the effect of fluid loss and training on the variables of acid-base balance has been studied (Abdoun et al. 2012; Okab et al. 2012). The influence of acid load with NH_4Cl on the acid-base status in young dromedary camels has also been reported (Elkhair and Hartmann 2010). In our clinic, the effects of tick infestation and semen collection by

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electroejaculation on the acid–base balance has been reported in dromedary camels (Tharwat et al. 2014; Tharwat and Al-Sobayil 2014). Evaluation of blood gases has also been reported in non-diseased camels, their neonates and blood of the umbilical cord at normal delivery (Tharwat 2015). Recently, alterations in the status of acid-base balance and blood gases were reported in camel with trypanosomiasis (Tharwat 2021b). However, acid-base balance and blood gases have not been carried out in camels with urinary disorders. Thus, this study was carried out to clarify the acid-base status and blood gases in camels with urinary tract disorders alongside the hemato-biochemical profiles compared to healthy camels.

MATERIALS AND METHODS

Ethical Approval

The Deanship of Scientific Research in the University of Qassim, Kingdom of Saudi Arabia approved the experimental procedures of this study (QU-IF-2-1-3-25436).

Camels, History, Physical Examination and Blood Sampling

Experimental protocol has been published elsewhere (Tharwat and Al-Sobayil 2016). Briefly, 29 camels (22 males and 7 females) were examined at the University Veterinary Hospital, Qassim University, Kingdom of Saudi Arabia during 2007 to 2016. The urinary disorders in the camels included cystitis, urine retention, hydronephrosis, red urine, renal masses, ruptured bladder and ruptured urethra. Camels were admitted to the clinic for examination due to complete loss of appetite, dysuria, pigmented urine, loss of body condition, decreased urine flow and/or complete absence of urine. Clinical screening consisted of inspection of the attitude and body status, examination of the cardiovascular, respiratory and digestive systems, measurement of rates of heart and respiratory system and body temperature, abdominal ballottement and rectal palpation. Fifteen camels with no history of previous illness were used as a control group. From each camel, 10mL of blood were gathered; 2mL in EDTA tubes, 2mL in heparinized tubes and the other 6mL in tubes-free of anticoagulants for serum harvesting. Diagnosis of renal disorders in the camels was established based on history, clinical examination, laboratory findings, urinary ultrasonography and post-mortem examination.

Measurement of Acid-base Status, Gases in Blood and Lactate Concentration

The blood samples in heparin tubes were examined at once for checking the variables of acid-base and blood gases using camel-side analyzer (I-STAT®, Abaxis, California, USA). In this method, blood pH, partial pressure of carbon dioxide (PCO_2), oxygen partial pressure (PO_2), bicarbonate (HCO_3), total carbon dioxide (TCO_2), oxygen saturation (SO_2), and lactic acid (LA) were analysed at once. The procedure of acid-base balance, blood gases and measurement of lactate were carried out as reported previously in camels (Tharwat and Al-Sobayil 2014; Tharwat et al. 2014; Tharwat 2015; Tharwat 2021b; Tharwat 202c; Tharwat and Al-Sobayil, 2022).

Determination of Hemato-biochemical Profiles

Total as well as differential white blood cells count, red blood cells (RBCs) count, packed cell volume (PCV), hemoglobin and RBCs indices were carried out on the EDTA sample using the VetScan HM5, Abaxis, California, USA. An automated analyzer (VetScan VS2, Abaxis, California, USA) was used to measure the concentrations of serum total protein, albumin, globulin, blood urea nitrogen (BUN), creatinine, calcium, magnesium and glucose. Values of serum γ-glutamyl transferase (GGT), aspartate aminotransferase (AST), creatine kinase (CK) and alkaline phosphatase (ALP) were also estimated by the VetScan VS2 analyzer.

Statistical Analysis

The results are tabulated as mean±SD and were analyzed using the SPSS statistical program, version 18, 2009. The Student's *t* test was used for comparisons and the level of significance was set at $P \leq 0.05$.

RESULTS

Table 1 shows classification of the 29 camels with different disorders affecting the urinary tract that were categorized into 7 groups. Table 2 summarizes the mean±SD of acid-base, blood gas parameters and lactate in camels with different urinary tract disorders alongside the 25, 50, 75, 95 and 99% percentiles compared to healthy controls. Fig. 1 illustrates the pH value where a significant decrease was detected in camels with urinary disorders versus healthy controls (P=0.02). Compared to a value of 7.54±0.16 in healthy camels, the blood pH in camels with urinary disorders was 7.30±0.15, with a statistically significant difference between them (P=0.02).

Table 1: Classification of urinary tract disorders in camels (n=29)

Group	Category	Number of diseased camels	Frequency (%)
1	Cystitis	5	17.2
2	Urine retention	4	13.8
3	Hydronephrosis	5	17.2
4	Red urine	4	13.8
5	Renal masses	2	6..9
6	Ruptured bladder	6	20.7
7	Ruptured urethra	3	10.3

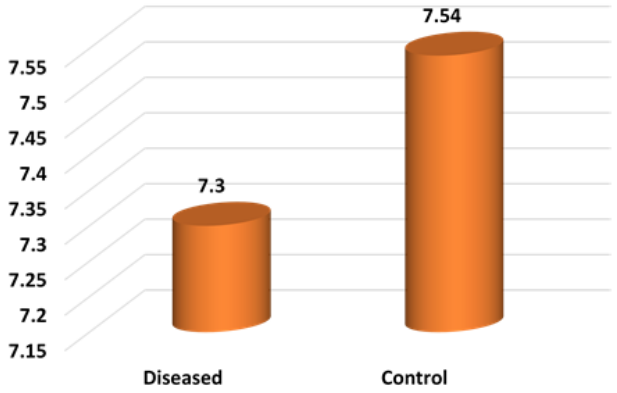

Fig. 1: The pH value in diseased camels with urinary disorders compared to healthy controls.

The HCO_3 level has decreased in diseased versus control camels (20.3±4.1mmol/L versus 24.9±2.9mmol/L in healthy camels; P=0.04). However, the PCO_2 was higher in camels with urinary disorders compared to healthy ones (43.9±4.7mmHg/L versus 30.0±8.1mmHg, P=0.0006). The PO_2 in this study was lower in camels with urinary disorders than healthy animals (30.0±19.9 mmHg/L versus 183±15mmHg/L, P=0.0001). However, the TCO_2 was higher in diseased than healthy camels (29.2±5.1mmol/L versus 25.7±2.9mmol/L, P=0.04). In contrast, the SO_2 was decreased in sick animals when compared to healthy ones (46.0±37.3mmol/L in diseased camels versus 100mmol/L in healthy camels, P=0.0001). Lactate concentration did not change in a significant manner between ill camels and controls (P>0.05).

The hematological alterations detected in camels with different urinary disorders are summarized in Table 3 compared to healthy controls alongside the 25, 50, 75, 95 and 99% percentiles. Neutrophilic leukocytosis and lymphopenia were the remarkable hematological changes in diseased camels when in comparison to healthy animals (P<0.05). The PCV, mean corpuscular hemoglobin and mean corpuscular hemoglobin concentration values were significantly low in camels with urinary disorders versus control camels (P=0.0001). The RBCs, hemoglobin and mean corpuscular volume mean values did not differ significantly in diseased camels when compared to controls (P>0.05).

Table 4 summarises serum biochemical variables in camels with different urinary disorders compared to healthy controls alongside the 25, 50, 75, 95 and 99% percentiles. Compared to healthy camels, the serum concentration of albumin was highly significantly decreased in camels with urinary diseases compared to controls (34.8±15.1g/L in diseased group versus 60.39±3.0g/L in healthy group, P=0.0001). In contrast, the globulin concentration was significantly high in camels with diseased animals compared to controls (38.2±21.1g/L in diseased group versus 7.0±3.8g/L in healthy group, P=0.0001). The concentrations of magnesium and glucose, and the activity of ALP, GGT and CK were significantly higher in diseased camels versus controls (P<0.05). The mean values of total protein, calcium and AST did not differ significantly in comparison to healthy animals (P>0.05). Fig. 2 and 3 show the BUN and creatinine values where significant elevations were detected in camels with urinary disorders compared to healthy controls (P=0.0001).

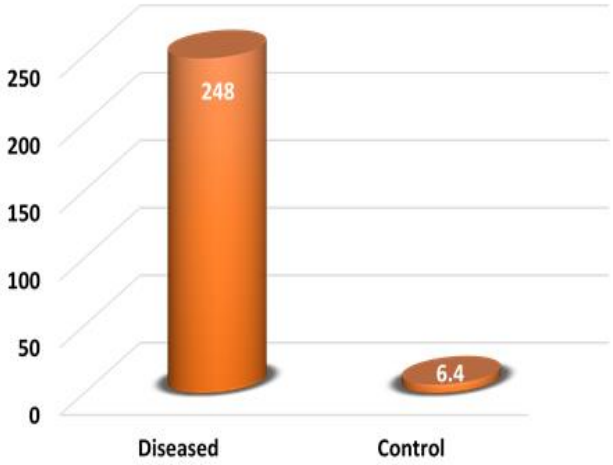

Fig. 2: The blood urea nitrogen (nmol/L) value in diseased camels with urinary disorders versus healthy controls.

Table 2: Acid-base balance, blood gases and lactic acid concentration in camels with urinary disorders versus healthy controls

Parameters	Units	Camels with urinary disorders (n=29)						Control camels (n=15)						*P* value
		Mean±SD	Percentiles					Mean±SD	Percentiles					
			25%	50%	75%	95%	99%		25%	50%	75%	95%	99%	
PCO_2	mmHg	43.9±4.7	39.6	44.9	47.5	48.8	49.1	30.0±8.1	22.6	31.6	36.7	40.9	40.9	0.0006
PO_2	mmHg	30.0±19.9	18.5	19.0	36.0	49.6	52.3	183±15	174	185	192	203.4	209.5	0.0001
HCO_3	mmol/L	20.3±4.1	18.5	20.9	22.0	24.6	25.3	24.9±2.9	23.7	25.1	27.0	28.3	28.9	0.04
TCO_2	mmol/L	29.2±5.1	25.3	29.0	33.5	34.8	35.0	25.7±2.9	24.8	26.0	27.3	29.1	29.8	0.04
SO_2 %	%	46.0±37.3	24.5	26.0	57.5	82.7	87.7	100	100	100	100	100	100	0.0001
LA	mmol/L	1.39±0.1	1.37	1.42	1.43	1.43	1.43	4.3±3.3	2.3	3.0	5.4	11.7	11.7	0.2

PCO_2, partial pressure of carbon dioxide; PO_2, partial pressure of oxygen; BE, base excess; HCO_3, bicarbonate; TCO_2, total carbon dioxide; SO2, oxygen saturation; LA, lactic acid.

Table 3: Hematological parameters in camels with urinary disorders versus healthy controls

Parameters	Camels with urinary disorders (*n*=29)						Healthy camels (*n*=15)						P value
	Mean±SD	Percentiles					Mean±SD	Percentiles					
		25%	50%	75%	95%	99%		25%	50%	75%	95%	99%	
WBCs ($\times10^9$/L)	43.4±33.4	31.6	43.4	55.2	64.6	66.5	16.8±3.9	15.7	17.9	18.6	21.3	22.3	0.0003
LYM ($\times10^9$/L)	1.5±0.6	1.2	1.5	1.7	1.9	2.0	6.2±2.9	4.4	5.9	6.6	11.1	12.9	0.03
NEU ($\times10^9$/L)	40.8±33.0	29.1	40.8	52.4	61.7	63.6	9.7±3.0	7.6	9.8	12.0	13.8	14.3	0.0001
RBCs ($\times10^{12}$/L)	8.4±1.3	7.9	8.	8.8	9.2	9.3	11.3±1.4	10.4	11.5	12.0	13.5	13.6	0.5
HB (g/dL)	11.7±	10.4	11.7	12.9	13.9	14.1	16.4±2.8	14.6	16.0	18.0	21.0	23.0	0.7
PCV (%)	25.0±3.3	24.04	25.0	28.0	28.0	28.0	28.9±2.7	27.4	29.0	30.5	33.0	33.2	0.0001
MCV (fl)	26.5±0.7	26.3	26.5	26.8	27.0	27.0	25.5±1.5	24.0	26.0	26.0	27.1	27.8	0.2
MCH (pg)	13.8±2.1	13.1	13.8	14.6	15.2	15.3	14.7±2.4	12.7	13.9	16.7	18.7	19.7	0.0001
MCHC (g/dL)	52.5±9.0	49.3	52.5	55.6	58.2	58.7	57.6±9.0	50.6	53.7	64.3	74.3	74.9	0.0001

WBCs, white blood cells; LYM, lymphocytes; MON, monocytes; NEU, neutrophils; RBCs, red blood cells; HB, hemoglobin; PCV, packed cell volume; MCV, Mean corpuscular volume; MCH, Mean corpuscular hemoglobin; MCHC, Mean corpuscular hemoglobin concentration.

Table 4: Biochemical parameters in camels with urinary disorders versus healthy controls

Parameters	Camels with urinary disorders (*n*=29)						Healthy camels (*n*=15)						P value
	Mean±SD	Percentiles					Mean±SD	Percentiles					
		25%	50%	75%	95%	99%		25%	50%	75%	95%	99%	
TP (G/L)	72.8±	60.0	81.0	82.0	82.0	82.0	67.3±4.3	63.0	67.5	68.8	74.0	76.4	0.09
ALB (G/L)	34.8±15.1	29.0	29.0	46.0	52.4	53.7	60.39±3.0	60.8	61.5	62.0	64.3	64.9	0.0001
ALP (U/L)	92±59	63	94	122	144	149	6.6±2.8	5.8	6.5	8.0	10.8	12.6	0.0001
AST (U/L)	84±29	65	79	82	123	131	79.5±16.5	69.5	80.5	85.0	104.8	118.6	0.6
CA (MMOL/L)	2.6±0.3	2.4	2.5	2.6	2.9	3.1	2.4±0.1	2.3	2.4	2.5	2.6	2.6	0.08
GGT (U/L)	15.3±5.7	13.0	17.0	18.5	19.7	19.9	12.2±5.3	8.8	12.5	13.0	19.8	26.4	0.005
GLOB (G/L)	38.2±21.1	28.0	31.0	53.0	63.4	65.5	7.0±3.8	5.0	7.0	9.0	12.5	15.3	0.0001
CK (U/L)	390±59	396	403	410	444	450	139.0±21.6	127.0	136.0	148.8	171.8	178.4	0.0001
MG (MMOL/L)	2.0±1.0	1.5	2.1	2.5	2.8	2.9	0.3±0.0	0.2	0.3	0.3	0.3	0.3	0.0001
GLU (MMOL/L)	9.9±1.2	9.8	10.2	10.5	10.9	11.1	5.7±0.6	5.3	5.6	6.1	6.4	6.6	0.0001

TP, total protein; ALB, albumin; ALP, alkaline phosphatase; AST, aspartate aminotransferase; CA, calcium; GGT, γ-glutamyl transferase; GLOB, globulin; CK, creatine kinase; MG, magnesium; GLU, glucose.

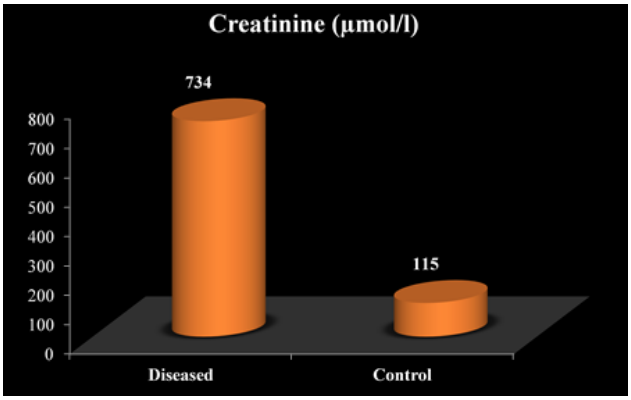

Fig. 3: The creatinine value in diseased camels with urinary disorders compared to healthy controls.

DISCUSSION

To the author's information, this study is the initial one that investigated the acid-base situation and blood gases in dromedary camels affected with different urinary disorders alongside hemato-biochemical parameters. Many dromedary camels are usually presented for veterinary clinics because of various conditions affecting the urinary tract (Tharwat and Al-Sobayil 2016; Tharwat et al., 2018a, b; Tharwat 2020a; Tharwat 2021a). The camels with different renal disorders in this study were diagnosed through history of the disease, clinical examination, laboratory profiles, urinary ultrasonography and diagnosis was confirmed finally at post-mortem examination.

Ultrasonography has been proved effective in evaluating camels with different thoracic, abdominal, hepatic and ophthalmic affections (Tharwat 2020b, c; Tharwat 2021c; Tharwat and El-Tookhy 2021). In this study diagnostic ultrasound was also effective in diagnosis and prognosis of camels with different urinary tract disorders. Results of transcutaneous and transrectal ultrasonography in the camels under investigation has been published previously (Tharwat and Al-Sobayil 2016). Transrectal ultrasonography showed a thick and corrugated mucosa of the urinary bladder in the first group and a distended urinary bladder with intact wall, peritoneal effusion and dilated pelvic urethra in the second group. In the third group, Transcutaneous and transrectal ultrasonography showed a distended renal pelvis. In camels with renal masses, transrectal ultrasonographic examination revealed echogenic masses in the left kidney. In camels with ruptured urinary bladder, transcutaneous ultrasonography showed anechoic peritoneal fluid where viscera are floating and postmortem findings included perforated urinary bladder, uroperitoneum and inflamed urinary bladder mucosa. In camels with urethral ruptured, transrectal imaging showed that the bladder is relatively of small size but with non-perforated wall (Tharwat and Al-Sobayil 2016).

Regulation of acid-base balance is carried out by the kidney through two pathways; (1) reabsorption of the filtrated HCO_3 and (2) forming of new HCO_3 by ammonia (NH_3) production and acid secretion through the distal nephrons (Siener 2018; Chen et al. 2019). In this study, the most remarkable finding in acid-base and blood gas changes were the metabolic acidosis in the camels with urinary disorders, a result agree well with human studies where metabolic acidosis was detected as sequelae to long-standing kidney affections and final stage renal disability in humans (Dhondup and Qian 2017). The decrease in blood pH could be easily justified by the increases in PCO_2 and additionally by the decreases in HCO_3 values. The decreased HCO_3 and TCO_2 in this study could be explained as being due to the metabolic acidosis. On the other side, lactate concentrations did not differ significantly between camels with urinary disorders and those healthy camels, and this may have been caused by the lowered metabolic signal during the diseased state. Lactate is a waste output through high potency exercise and is also an important substance that greatly share to the production of energy in different body organs (Tharwat 2021b, c).

The detected neutrophilic leukocytosis in the camels with urinary tract diseases in this study may be due to primary or secondary bacterial infection to the camels with inflammation of the urinary bladder, urine retention, hydronephrosis, renal abscessations, ruptured urinary bladder and ruptured urethra or on the base of the inveterate nature of the affection. The detected neutrophilic leucocytosis has also been reported in camels with uroperitoneum du to ruptured urinary bladder (Tharwat et al. 2012). The increased serum concentrations of BUN and creatinine in the camels with renal disorders in this study have also been reported in camels with uroperitoneum du to ruptured urinary bladder (Tharwat et al. 2012). The mean values of total protein, calcium and AST did not differ significantly in comparison to healthy animals (P>0.05).

In conclusion, in comparison to the healthy controls, the blood pH, HCO_3, PO_2 and O_2 are lower in camels with urinary disorders; however, the PCO_2 and TCO_2 were higher in the diseased camels versus healthy animals. Additional outstanding results in diseased camels include neutrophilic leukocytosis, hypoalbuminemia, hyperglobulinemia, hyperglycemia, and increased concentrations of BUN and creatinine. This study has one limitation. The results of different urinary tract disorders were tabulated collectively; the conclusion was therefore unable to point out that which urinary disorder has more or less changes in acid base status, blood gases and hemato-biochemical parameters. Another research is therefore needed to clarify these points in details.

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