

Evaluation of isoflurane anesthesia after xylazine/ketamine administration in dromedary camels

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Abstract: The objective of this study was to evaluate isoflurane after premedication with xylazine and induction with ketamine in camels. Six healthy adult female dromedary camels were premedicated with xylazine (0.2 mg/kg, IV). Twenty minutes later, anesthesia was induced with ketamine (2 mg/kg, IV) and was maintained with isoflurane in 100% oxygen. Onset and duration of anesthesia were recorded. Rectal temperature, respiratory rate, heart rate, oxygen hemoglobin saturation, and blood pressure were measured before and 20 min after xylazine administration and every 10 min thereafter until recovery. Lead II electrocardiogram was used to monitor camels for the presence of arrhythmias. Venous and arterial blood samples were taken for hematological examination and blood gases and pH, respectively. The results are thought to be the first detailed evaluation of isoflurane anesthesia in dromedary camels. Significant decrease in heart rate after xylazine/ketamine administration and significant decreases in rectal temperature and arterial blood pressure were recorded in camels during isoflurane administration. However, percentage of oxygen hemoglobin saturation significantly increased with significant changes in complete blood count and minor changes in arterial pH, PCO₂, and PO₂ during the study. The quality of anesthesia and recovery was good to excellent. In conclusion, isoflurane resulted in smooth recovery without complications and can be considered a good inhalation anesthetic for camels.

Key words: Anesthesia, camel, inhalation, isoflurane, ketamine

1. Introduction

The use of inhalation anesthetics in large animals is increasing, especially for prolonged procedures. Advantages of inhalation anesthetics include their elimination mainly through the respiratory tract, the fact they do not accumulate during long procedures or require extensive metabolism for termination of their effects, and their maximum effectiveness and safety, provided that appropriate adaptations are made for fasting and positioning of ruminant animals (1). Sedation and induction of inhalation anesthesia are very important in large, aggressive animals. Xylazine is one of the α_2 -adrenoceptor agonists that are potent analgesics and reduce the minimum alveolar concentration of inhalational agents (1). Ketamine is a short-acting dissociative that produces anesthesia with moderate analgesia (2). Xylazine and ketamine have been used for premedication and induction in large animals (3,4).

Although descriptions of general anesthetic techniques with isoflurane are readily available for animals (1,4,5),

no information has been published that evaluates isoflurane for dromedary camels. Therefore, the aim here was to evaluate isoflurane as an inhalation anesthetic in dromedary camels after premedication with xylazine and induction with ketamine.

2. Materials and methods

The experimental protocol was approved by the Ethics Committee for Animal Research, Scientific Research Deanship, Qassim University, Saudi Arabia. Food and water were withheld for 48 h and 24 h respectively for 6 healthy adult female dromedary camels (mean body weight = 378 kg, range = 321–503 kg; mean age = 7 years, range = 5–12 years).

Sixteen-gauge intravenous (IV) and 20-gauge intraarterial catheters (Mais Co., Riyadh, Saudi Arabia) were placed in the left jugular vein and auricular artery (occasionally the radial artery), respectively, after surgical preparation and local infiltration of skin with 1 mL of lidocaine. Camels were premedicated with

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xylazine (Bomazine 10%, BOMAC Laboratories Ltd., New Zealand) at 0.2 mg/kg, IV. Twenty minutes later, anesthesia was induced with ketamine (Alfasan, Woerden, the Netherlands) at 2 mg/kg, IV.

A cuffed endotracheal tube (20 mm) was inserted while the camel was in the kush position ($n = 5$) or in right lateral recumbency ($n = 1$). The head was pulled to a straight position, the oral cavity was opened wide by mouth gag, and the tongue was pulled laterally. The anesthetist palpated the larynx from outside using the left hand and then moved toward the mouth. The anesthetist's right hand was introduced to locate the epiglottis, and an endotracheal tube was then inserted by an assistant. Camels were then moved onto a padded operating table (in a temperature-controlled room maintained at 21–24 °C) and positioned in right lateral recumbency. The anesthetized camel was connected with a semiclosed-circle rebreathing anesthetic machine (SurgiVet Foal Circuit Set, Smith Medical North America, Waukesha, WI, USA). Anesthesia was maintained with isoflurane (Floran, HIKMA Pharmaceuticals, Amman, Jordan) in 100% oxygen at a flow rate of 6 L/min. Anesthesia was discontinued after 1 h and camels received supplemental oxygen (6 L/min) through the endotracheal tube. After extubation, oxygen was insufflated through nasal tube until sternal recumbency.

Rectal temperature (RT), respiratory rate (RR), heart rate (HR), oxygen hemoglobin saturation (OHS), systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial blood pressure (MBP) were measured before and 20 min after administration of xylazine, and then every 10 min until recovery. RT was recorded by digital thermometer, and RR was counted by watching the movement of either the thoracic wall or the rebreathing bag. A pulse oximeter (504DX Digital Oximeter, Criticare Systems Inc., Waukesha, WI, USA) with a probe attached to the tongue was used to determine OHS; HR, SBP, DBP, and MBP were indirectly measured with the oscillometric technique (Accutorr Plus Recorder, Datascope Corp., Paramus, NJ, USA), using a cuff placed around the tail. Lead II electrocardiogram (Kenz Cardico 302, Suzuken Co., Tokyo, Japan) was used to monitor camels for the presence of arrhythmias. Depth of anesthesia was determined by recording palpebral, jaw, tongue, ear, and anal reflexes.

Times of first limb movement, regaining swallowing reflex and extubation, sternal recumbency, and standing were recorded. Quality of recovery was also recorded. All camels were extubated upon regaining swallowing reflexes. Subjective scores for overall quality of recovery (1 = poor; 2 = marginal; 3 = fair; 4 = good; 5 = excellent) from two observers were averaged to provide an overall recovery score. A score of 1 was associated with multiple,

uncoordinated attempts to achieve sternal or standing posture resulting in a major or life-threatening injury. Score 2 was associated with excitement, paddling when recumbent, several attempts to stand, severe ataxia once standing, possible falls, and danger of self-inflicted injury. Score 3 showed some staggering and ataxia, a few unsuccessful attempts to stand, and ataxia immediately after standing up. Score 4 presented signs of slight ataxia and staggering, standing at first or second attempt, and no serious instability. A score of 5 was associated with fewer than 3 quiet, coordinated efforts to attain a sternal or standing posture.

Jugular blood samples were collected into EDTA-containing Vacutainer tubes immediately before and 20 min after xylazine and then every 10 min until complete recovery. Red blood cell counts (RBC), white blood cell counts (WBC), differential leukocytic counts (dWBC), packed cell volume (PCV), hemoglobin concentration (HB), hematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), and platelet counts (PLT) were determined by using an automated machine (Vet Scan HM5, ABAXIS, Union City, CA, USA). Arterial blood samples were collected at the same intervals as venous samples in heparinized Vacutainer tubes for immediate measurements of PO_2 , PCO_2 , and pH using a blood gas analyzer (GEM Premier 3000, Instrumentation Laboratory Co., Bedford, MA, USA).

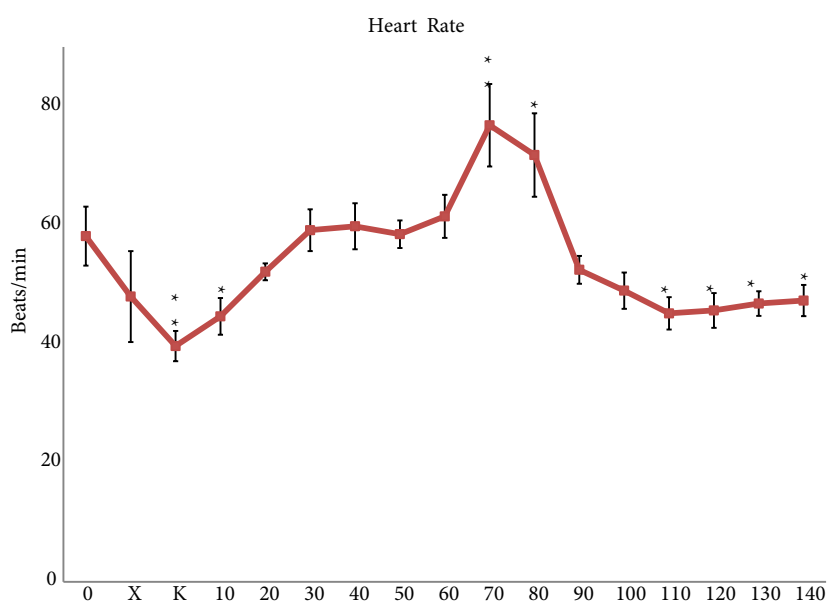
Data were expressed as mean \pm SEM and analyzed with a commercial statistical software package (SPSS 18.0, SPSS Inc., Chicago, IL, USA). Repeated measures analysis of variance was used as a statistical model to evaluate differences over time in dependent variables, including parameters of physiological and hematological functions. Duncan's test was used to calculate multiple comparisons. Results were considered significant at $P < 0.05$.

3. Results

Camels showed a decrease in spontaneous activity at 11 ± 2.4 min of xylazine administration with lowering of head and neck, dropping of lower lip, and protrusion of tongue. Although camels sat in sternal recumbency, the head and neck rested on the floor 8 ± 2.1 min after ketamine administration. The eyeballs were centrally positioned during anesthesia. Monitoring of reflexes is summarized in Table 1. Quality of anesthesia was good in 1 (16.7%) and excellent in 5 (83.3%) of the camels. Mean set value of vaporizer was 3.53% (range: 2%–4%). There were significant changes in HR (Figure 1), RT (Figure 3), MBP (Figure 4), and OHS (Figure 5), and insignificant changes in RR (Figure 2). Changes in blood constituents and blood gases are summarized in Table 2.

Table 1. Status of reflexes monitored during xylazine, ketamine, and isoflurane anesthesia and during recovery in dromedary camels (n = 6).

Reflex	Xylazine	Ketamine	Isoflurane	Recovery
Tongue protrusion	Protruded after 10 min	Protruded	Protruded	Drawn after 30 min
Ear reflex	Present	Disappeared after 10 min	Disappeared	Active after 20 min (n = 3), 40 min (n = 5), 50 min (n = 6)
Muscle relaxation	Absent	Appeared after 10 min	Appeared	
Palpebral reflex	Present	Present	Absent after 10 min (n = 1), 20 min (n = 6)	Active after 10 min (n = 4), 20 min (n = 6)
Anal dilatation with exposure of rectal mucosa	Absent	Absent	Present after 10 min (n = 3), 20 min (n = 6)	Absent after 20 min

**Figure 1.** Changes in HR in dromedary camels (n = 6) at 0 time, after xylazine and ketamine administration, during isoflurane, and at recovery.

X = Xylazine, K = ketamine. *: Value is significantly different from the 0 time value. **: Value is highly significantly different from the 0 time value.

Changes in ECG results revealed normal sinus rhythm recorded before premedication; however, bradyarrhythmia, with increased PR and ST intervals, was recorded after xylazine. Relative tachyarrhythmia was observed after induction when compared with the graph after xylazine. An inverted T-wave occurred during the study in all camels, and an increased intensity of T-wave was recorded 5 min after xylazine. Intensity of T-wave decreased after ketamine, during isoflurane, and during recovery. Quality of recovery was good (score 4) in 3 (50%) and excellent (score 5) in 3 (50%) of the camels. Signs of recovery are illustrated in Table 3.

4. Discussion

These results are apparently the first detailed evaluation of isoflurane anesthesia in dromedary camels. Xylazine, however, caused mild salivation, drooping of lower lips, and relaxation of the neck in the present camels, findings that had been cited in another study (6). Tongue protrusion occurred in camels after xylazine administration, which is similar to the results of another study in water buffaloes (1). Endotracheal intubation has been cited as being difficult in camels because of the narrow oral space (7). However, muscle relaxation and analgesia resulting from xylazine/ketamine administration was helpful in intubation of our camels and the modified intubation

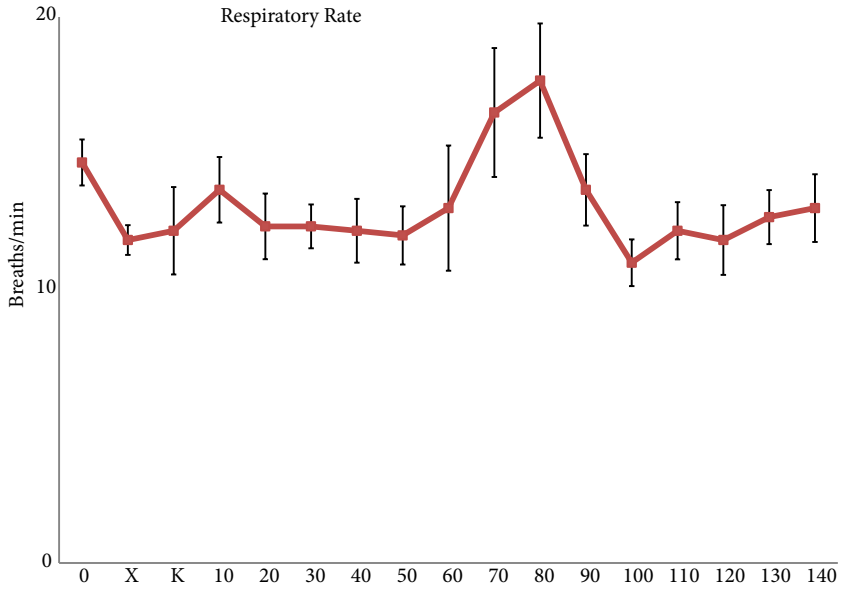


Figure 2. Changes in RR in dromedary camels (n = 6) at 0 time, after xylazine and ketamine administration, during isoflurane, and at recovery. X = Xylazine, K = ketamine. *: Value is significantly different from the 0 time value. **: Value is highly significantly different from the 0 time value.

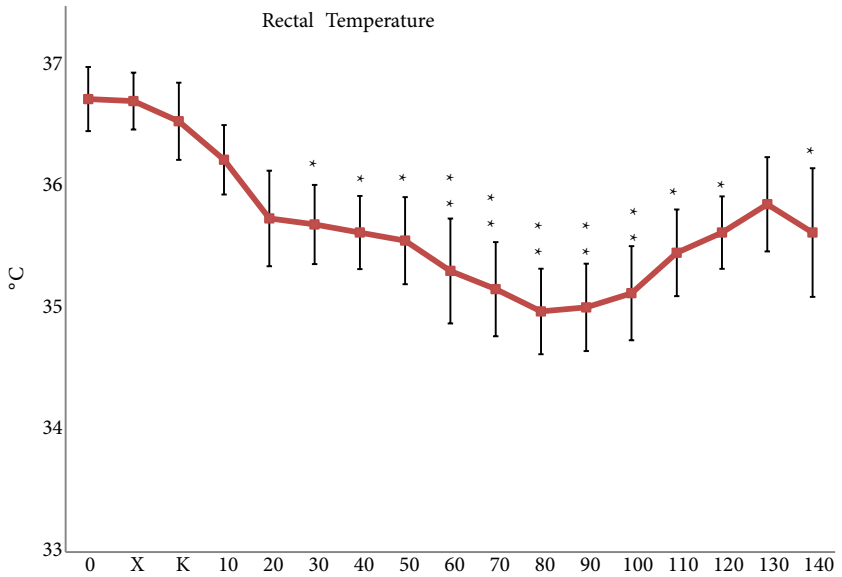


Figure 3. Changes in RT in dromedary camels (n = 6) at 0 time, after xylazine and ketamine administration, during isoflurane, and at recovery. X = Xylazine, K = ketamine. *: Value is significantly different from the 0 time value. **: Value is highly significantly different from the 0 time value.

technique did not require the use of a stylet in the camels of the present study.

Testing reflexes in our camels and in other animals (1,8) was suitable for monitoring the quality of the anesthesia. The eyeball position in camels was central, unlike that of

cattle, in which the eyeball is ventrally rotated and partially or completely hidden under the lower eyelid (9).

Xylazine has also been found to decrease HR, cardiac output, and ABP in different animal species (10,11). Hypotension, which was not correlated with bradycardia,

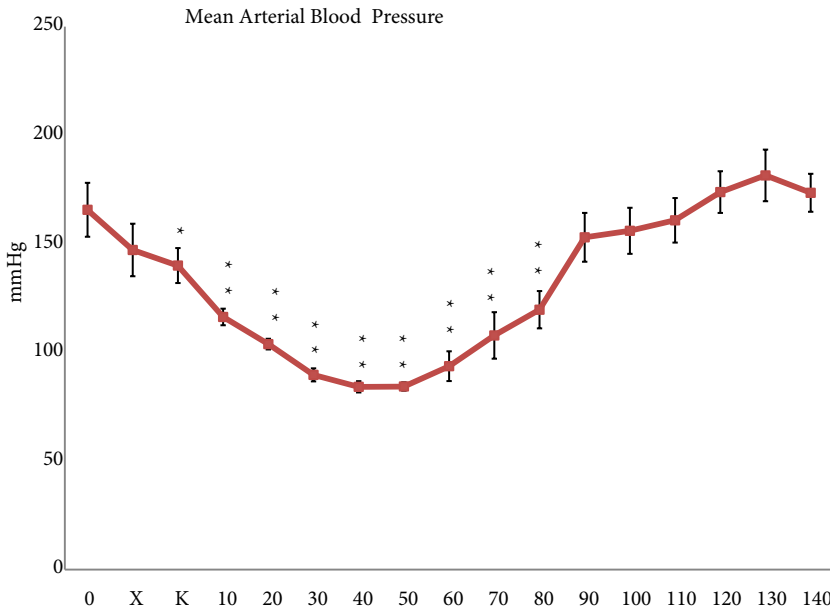


Figure 4. Changes in MBP in dromedary camels (n = 6) at 0 time, after xylazine and ketamine administration, during isoflurane, and at recovery. X = Xylazine, K = ketamine. *: Value is significantly different from the 0 time value. **: Value is highly significantly different from the 0 time value.

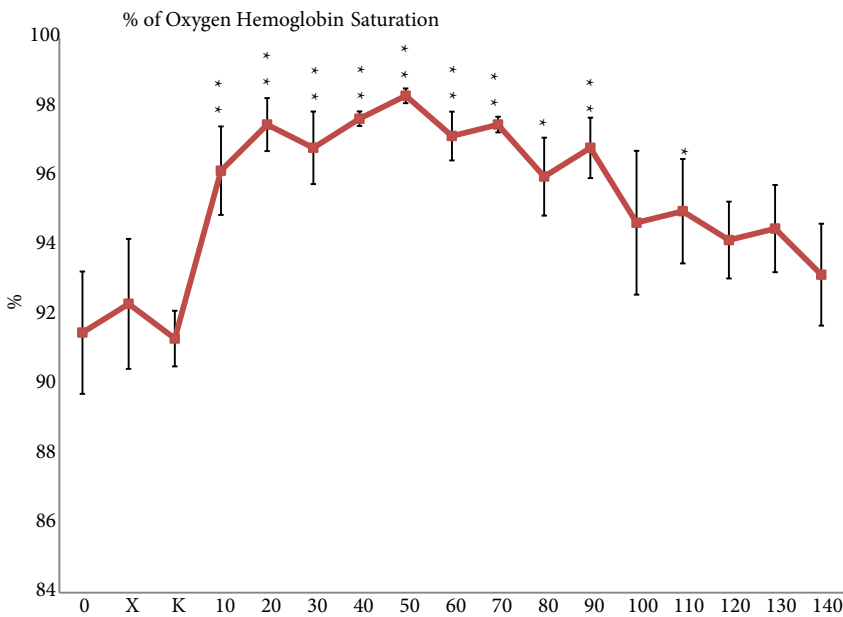


Figure 5. Changes in % of OHS in dromedary camels (n = 6) at 0 time, after xylazine and ketamine administration, during isoflurane, and recovery. X = Xylazine, K = ketamine. *: Value is significantly different from the 0 time value. **: Value is highly significantly different from the 0 time value.

has occurred in camels after xylazine administration (6). Ketamine has been reported to increase HR and arterial BP as a result of direct stimulation of the CNS (12).

Unexpectedly, there was a significant decrease in the HR of these camels. This might have been due to the action of xylazine masking the action of ketamine.

Table 2. Mean (\pm SEM) values of CBC in dromedary camels (n = 6) after xylazine and ketamine administration and during isoflurane anesthesia.

Time (min)	Mean (\pm SEM)								pH	PCO ₂ (mmHg)	PO ₂ (mmHg)
	RBCs ($\times 10^{12}/L$)	WBCs ($\times 10^9/L$)	PLT ($\times 10^9/L$)	HB (g/dL)	MCV (fL)	HCT (%)	MCH (pg)	MCHC (g/dL)			
0	6.4 (0.7)	10.3 (1.2)	861.5 (304.2)	16.7 (1.1)	20.5 (5.6)	13.1 (1.4)	26 (9.9)	36 (0)	7.34 (0.02)	49.17 (3.3)	142.67 (38.5)
X	6.51 (1.1)	15.2 (2.7)*	315.8 (131.4)**	16.3 (1)	22 (3.8)**	14.3 (2.8)	25.1 (9.1)	44.8 (8.8)	7.33 (0.03)	53.67 (2.5)	79.33 (27.5)
K	7.95 (0.2)**	14.6 (1.3)**	163.5 (20.5)**	17.7 (0.2)	25.3 (0.2)**	20.2 (0.4)**	21.8 (0.6)**	87.8 (1.9)*	7.32 (0.02)	64.33 (3.2)*	170.33 (17.4)
20	9.06 (0.3)**	13.58 (1.6)	100.3 (0.6)**	16.5 (0.5)	25.3 (0.2)**	23 (0.7)**	17.8 (0.8)**	72 (2.9)**	7.34 (0.02)	53.33 (4.7)	85.67 (37.2)
40	8.44 (0.2)**	13.32 (1.8)	100 (0)**	15.5 (0.6)	25.5 (0.2)**	21.3 (0.6)**	18 (0.5)**	73 (2)**	7.45 (0.05)**	43.17 (6.9)	178.5 (21.5)
60	7.66 (0.4)**	11.67 (0.6)	176.3 (59.6)**	14.3 (0.6)*	26.7 (0.2)**	20.3 (1.1)**	18.2 (0.7)**	70.5 (2.2)**	7.38 (0.04)	49.83 (5.7)	132.67 (33.6)
80	8.51 (0.4)**	18.6 (1.3)**	175.8 (30.9)**	16.3 (0.4)	26.2 (0.2)**	21.5 (1)**	19.3 (1.1)**	75 (4.4)**	7.43 (0.02)	41.83 (2.1)	53.33 (2.4)*
100	7.53 (0.2)**	18.32 (1.6)**	163.5 (17.9)**	12.8 (0.5)**	26.5 (0.2)**	20.1 (0.4)**	16.5 (0.4)**	63.3 (1.4)**	7.37 (0.03)	50.67 (5)	127 (20)
120	8.54 (0.3)**	23.83 (1.7)**	203.3 (31.7)**	15.7 (0.7)	23.7 (0.8)**	20.4 (0.9)**	17.7 (0.8)**	76.9 (5)**	7.52 (0.05)**	42 (5.5)	87.5 (12.3)
140	8.47 (0.2)**	27.15 (0.6)**	222.7 (36.9)**	13.2 (0.3)**	23 (0)**	19.3 (0.5)**	15.5 (0.4)**	69.7 (1.9)**	7.36 (0.04)	52.33 (4.8)	118 (20.5)

X = Xylazine, K = ketamine. *: Value is significantly different from the 0 time value. **: Value is highly significantly different from the 0 time value.

Table 3. Mean (\pm SEM) times of signs of recovery from isoflurane anesthesia in dromedary camels (n = 6).

Sign	Mean time (\pm SEM) of recovery in minutes (range)
First limb movement	18.5 (4.3) (7–37)
Swallowing reflex and extubation	19.33 (4.6) (8–37)
Sternal recumbency	54.67 (7.2) (23–68)
Standing time	91.67 (10.5) (55–125)

In the camels here, isoflurane caused significant decreases in RT and ABP and a nonsignificant decrease in RR. Similar results in other animals have been cited (13). However, it has been reported that ABP measurements confirmed hypertension in cattle during isoflurane (14). In other studies, an increase in RR was recorded in goats (15) and in buffaloes, with a significant decrease in HR (1). The relatively higher concentrations of isoflurane used in our study might have been a factor in decreasing ABP. The effect of inhalation anesthetics on HR has been shown to be variable and dependent on agent and species (16). HR in humans and dogs has been reported to increase

with isoflurane (16). The decrease in BP found in the camels of the current study might be related to a decrease in stroke volume and decrease in peripheral vascular resistance, which has been cited elsewhere (16). The decrease in RT recorded in the camels of the present study was similar to the findings of another study in buffaloes (17). This decrease in RT was attributed to the decrease in basal metabolic rate during anesthesia (17). Moreover, inhalation of isoflurane in 100% oxygen has been reported to increase OHS in buffaloes (17), much like the findings of the current study in our camels. ECG findings of the camels revealed bradyarrhythmia after xylazine and

inverted and decreased intensity of T-waves after ketamine administration, during isoflurane, and during recovery. It has been reported that α_2 -agonists cause heart block and bradyarrhythmia (18). The most commonly encountered arrhythmogenic effects of xylazine include sinoatrial block, atrioventricular block, bradycardia, first- and second-degree heart block AV dissociation, and sinus arrhythmia (19,20). Electrocardiography has revealed first-degree atrioventricular block, sinoatrial block, sinus arrhythmia, and wandering pacemaker in the sinoatrial node (6). Moreover, the configuration and magnitude of the T-waves vary considerably among species (18). Isoflurane has been reported to affect the passive electrophysiological properties of the heart by changing membrane fluidity and depressing gap junctions, resulting in cardiac arrhythmias and mechanical contraction abnormalities. Isoflurane has also been cited as sensitizing the myocardium to catecholamines and producing pronounced effects upon HR and rhythm because of general membrane depressant effects (18).

Although there were minor changes in arterial pH, PCO_2 , and PO_2 in our camels, arterial PCO_2 increased significantly after ketamine. The increase in arterial PCO_2 in this study indicated respiratory depression after ketamine administration. Isoflurane has been found to induce respiratory depression during spontaneous breathing, which was manifested by elevated arterial PCO_2 in cattle (14). An increase in arterial PO_2 and PCO_2 and a decrease in arterial pH have been recorded in animals under isoflurane anesthesia (8,15,21). The variations between these results and the present study might be attributed to variations in concentration of isoflurane. The most frequently used index of respiratory system response to general anesthetics has proved to be arterial PCO_2 (16). All inhalation anesthetics have been found to depress alveolar ventilation and increase arterial PCO_2 . Arterial PCO_2 has been reported to have a direct depressant action on the heart and on smooth muscle of peripheral blood vessels and to cause indirect stimulation of the circulatory

function (16). The significant decrease in arterial PO_2 in the camels 20 min after discontinuing isoflurane might be due to the switch from breathing oxygen to air.

The significant increases in complete blood count (CBC) values during isoflurane might be due to splenic compromise and stress before and during induction. However, there were decreases in PLT count, HB, and MCH after xylazine/ketamine administration, during isoflurane, and during recovery. Significant decrease in HB was recorded in buffaloes during isoflurane (1) with different results concerning other hematological parameters. Platelet count decreased significantly after xylazine in other camels (22,23), which has been attributed to hemodilution or increased spleen storage function (22). Different results have been reported in sheep (8), in which there was a decrease in RBC during isoflurane. This decrease in the RBC count of sheep has been attributed to sequestration of RBCs in the spleen or by the shifts in body fluids (8).

Time to sternal recumbency in camels was recorded to be about 1 h, while time to standing was about 1.5 h, which was longer than that recorded in cattle and horses. Variable results have been reported in animals (24–26). Rapid recovery has been reported to be advantageous in ruminants in order to reduce risk of regurgitation (26). Quality of recovery in our camels was good to excellent. Similar results have been reported in horses (24) and cattle (14). Ruminal regurgitation was not recorded in the current camels, although it has happened in cattle (14).

Slight modification facilitated intubation in camels after ketamine administration. Except for RT, maintenance of isoflurane anesthesia had only a minor effect on the physiological parameters. It had a significant lowering effect on BP and there was a significant increase in OHS. There were significant changes in CBC and minor changes in arterial pH, PCO_2 , and PO_2 . Quality of anesthesia and recovery was good to excellent in all camels without ruminal regurgitation.

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