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Reference Values for Blood Gas Analysis, Electrolytes and Critical Biochemical Variables for Short-Hair-English and Duncan-Hartley Guinea Pigs Anaesthetized with Xylazine-Ketamine

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Abstract: The objective of this study was to establish a range of reference values for blood gas analysis, electrolytes, hematocrit and critical blood variables for guinea pigs anaesthetized with xylazine-ketamine. The influence of the strain (short hair English vs. Duncan-Hartley) was also evaluated. Blood was obtained by cardiocentesis from 40 clinically healthy 8-11 weeks old female adult guinea pigs. Results indicated the following values: pH (7.28-7.55 vs. 7.38-7.53), PCO_2 (28-42 vs. 33-44 mmHg), PO_2 (18-70 vs. 25-52 mmHg), Na^+ (124-141 vs. 126-137 mmol L^{-1}), K^+ (3-7.5 vs. 3.6-4.6 mmol L^{-1}), Ca^{2+} (0.52-1.28 vs. 1.28-1.47 mmol L^{-1}), glucose (64-190 vs. 98-211 mg dL^{-1}), lactate (1-5 vs. 0.3-6.6 mg dL^{-1}) and hematocrit (27-40 vs. 38-49%) for short hair English and Duncan-Hartley guinea pigs, respectively. No differences in the guinea pigs electrolytes or blood gas analysis were found. However, we can confirm that the individual's pigmented short hair English strain showed the most favorable results in regard to the PCO_2, Ca^{2+} and haematocrit values when submitted to the sedation combination of xylazine-ketamine.

Key words: Guinea pig, blood gases, electrolytes, reference ranges, short hair English, Duncan-Hartley

INTRODUCTION

The pigmented strain guinea pigs (*Cavia porcellus*) are generally used in auditive investigation (Brown *et al*., 1989), whereas the Duncan-Hartley strain of guinea pigs are commonly used in a variety of biomedical research (Buchanan *et al*., 1998; Ozbek *et al*., 2004; Schwenke and Cragg, 2004), where blood samples are frequently required and is most common (Sanchez-Aparicio *et al*., 2008). The techniques used must be refined due to the stress caused in the individual from which, the sample is taken and can affect the physiological variables (Hernadez-Gonzalez *et al*., 2006).

Blood samples are taken from guinea pigs under anesthesia in order to help immobilize them and minimize stress, guaranteeing more reliable results, especially when, working with blood gas samples (Sanchez-Aparicio *et al*., 2007, 2008). Unfortunately for many years, guinea pigs have been described as rodents hard to effectively anesthetize without compromising their cardio-respiratory stability (Green *et al*., 1981; Brown *et al*., 1989; Flecknell, 1996; Buchanan *et al*., 1998; Schwenke and Cragg, 2004). Many investigators have evaluated different types of anesthesia and possible combinations of them (Hart *et al*., 1984; Flecknell, 1996) the most frequently used is xylazine-ketamine

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(Green *et al*., 1981; Jacobson, 2001). Ketamine is classified as a dissociative anesthesia that causes a cataleptic state accompanied by cardiovascular and sometimes cause respiratory depression, whereas xylazine is classified as α_2 adrenoceptor agonist sedative relaxer that causes superficial and visceral analgesia (Hart *et al*., 1984; Buchanan *et al*., 1998). Most studies indicate that the combined administration of xylazine-ketamine does not have significant negative effects on blood gas and body temperature parameters for guinea pigs (Brown *et al*., 1989; Jacobson, 2001). This is why the xylazine-ketamine anesthesia combination is used extensively (Jacobson, 2001; Schwenke and Cragg, 2004; Sanchez-Aparicio *et al*., 2008). Measurement, knowledge and interpretation of blood gas is complemented with electrolyte, glucose, lactate and haematocrit values providing essential clinical information on the state of the patient and can help clinicians and investigators in evaluation, handling and care of the patient in order to make therapeutic decisions and avoid putting the patient animals under study at risk (Strickland *et al*., 1984; Hernadez-Gonzalez *et al*., 2006; Trujillo-Ortega *et al*., 2007; Olmos-Hernandez *et al*., 2008). However, few studies on blood gas levels have been reported for this species (Lall and Buckner, 1976; Bar-llan and Marder, 1980; Hart *et al*., 1984). Thus, the objective of this study was to establish reference values for blood gases, serum electrolytes, glucose, lactate and hematocrit in the arterial blood of guinea pigs using xylazine-ketamine. The influences of the strain (short hair English vs. Duncan-Hartley) were tested for hematic indicators as well.

MATERIALS AND METHODS

Type of animals and location: The animals used in this study were guinea pigs (*Cavia porcellus*) from two strains: short hair English and Duncan-Hartley, kept under controlled biotery conditions.

The study was approved and registered by the Committee of Animal Investigations (CINVA) at the Instituto Nacional de Ciencias Medicas y Nutricion Salvador Zubiran (INCMNSZ), Mexico DF. During all the steps of the study, the animals were cared for according to the Official Norma Mexican NOM-062-ZOO (1999), specifications techniques of reproduction, care and use of laboratory animals.

Number of animals and group formation: Females were clinically evaluated by a medical veterinarian a las 8:00 am, aproximadamente 4 h previas a la anesthesia the day the blood samples were taken, only animals that showed no sign of clinical illness were used. Forty (female adult) guinea pigs from 8-11 weeks old weighing 584-624 g were included in the study; 20 of these guinea pigs were randomly selected from a population of 48 short-hair English females and included in group 1; another 20 guinea pigs were randomly selected from 62 Duncan-Hartley females and included in group 2.

Blood samples: The animals included in this study were handled gently and orderly. The guinea pigs were anesthetized with 3 mg kg^{-1} xylazine (Rompun Vet®, Bayer SA, Mexico) and 50 mg kg^{-1} ketamine (Ketalar®, Pfizer, Mexico) simultaneously and intraperitonealy. Afterwards, they were placed in sterilized polycarbonate cages while waiting for the anesthesia to take effect. The animals were carefully immobilized by all four extremities and placed in a dorsal recumbency on a veterinary operating table. Once absences of reflections were confirmed, the thoracic area was shaved with an electric shaver (WAHL, precision WAHL®, USA).

Twenty to twenty five minutes after the anesthesia was applied, the blood sample was taken using a sterile syringe gauge 23 G×1". The process was carried out by inserting the syringe behind the xiphoid with the needle pointing cephalad in order to access the heart and obtain 1 mL of blood. Part of the blood obtained was transferred to a 150 μL heparinized micro capillary tube (lithium) and then processed by analyzing the gases and electrolytes in the blood, through a third generation critical blood Gas-Meter (GEM premier 3000, Instrumentation Laboratory Diagnostics, USA and Italy). Two minutes later the following parameters were obtained: pH, partial CO_2 pressure and O_2 (mmHg), serum electrolytes: Na^+, K^+ and Ca^{2+} (mmol L^{-1}); glucose (mg dL^{-1}) and lactate (mg dL^{-1}), hematocrit (%) and total blood calculated parameters (carbonate (HCO_3^-) (tCO_2), calculated oxygen saturation (SO_2c), concentration of Total Hemoglobin (THbc)). The samples were analyzed and obtained in the same order. Finally, all the guinea pigs were sacrificed with an intramuscular overdose of sodium pentobarbital, according to that which is established in the Official Norma Mexican NOM-033-ZOO (1995) that references humane sacrifice of domestic and wild animals.

Statistical analysis: Descriptive statistics were taken for each group in the study: dispersal measurement: standard deviation, variation and coefficient, mode, minimum and maximum. With the objective of finding differences between strains that data was consolidated as mean±SD and were compared between groups by a student t-test, assuming equality in variances the statistical analysis was carried out with the SAS ver. 6.12 program by one of the investigators ignoring the distribution of data in groups.

With the purpose of establishing greater reliability, results were simultaneously used in the student-t and the Wilcoxon rank sum test.

RESULTS

The results of the descriptive statistics for gas in the blood, electrolytes, substrates, hematocrit and calculated parameters in blood total for short hair English and Duncan-Hartley guinea pig strains are shown in Table 1 and 2, respectively, with the intention of characterizing the reference value ranges under the influence of anesthesia (3 mg kg^{-1} xylazine and 50 mg kg^{-1} ketamine) in each strain.

Short hair English: We observed little variation in the pH parameter for short hair English guinea pig due to a coefficient variation of 0.89%. The value with the greatest frequency in the data distribution was 7.48, whereas the minimum and maximum value was 7.28-7.55, respectively. Regarding CO_2 partial pressure, we observed a coefficient variation equal to 14.57%, the value most frequently registered in data combination was 31 mmHg, the range of data reported for this variable fluctuated between 28-42 mmHg (Table 1).

Regarding electrolyte parameters and specifically the Na^+, a registration coefficient variation of 2.83% was obtained, while we observed that the value with the greatest frequency was 131 mmol L^{-1}. It is worth mentioning that data dispersion in the population expressed as minimum and maximum for sodium was 125-141 mmol L^{-1}, respectively. Regarding the K^+ parameter a coefficient variation of 24.49% was observed, the greatest frequency registered was 3 mmol L^{-1}. We observed little variance in the rectal temperature of the short hair English guinea pigs, with to a coefficient variation of 1.59%, assuming that the value of 37.5°C was most frequent and the range of temperature registered in this strain of guinea pigs varies between 36.7-38.7°C (Table 1).

Duncan-Hartley: We observed an almost imperceptible variation in the pH parameter in the Duncan-Hartley guinea pigs strain, with a coefficient variation of 0.60%. The numeric value most frequently registered in the data distribution was 7.39, whereas the minimum and maximum values were 7.38-7.53, respectively. Regarding the CO_2 partial pressure, we observed a relatively low coefficient variation of 7.09%, the value registered with the highest frequency for combined data was 40 mmHg and the range reference observed varied between 33-44 mmHg (Table 2).

Concerning electrolytes, we obtained a coefficient variation of 1.95% for the Na^+ parameter, the value registered with greatest frequency was 132 mmol L^{-1} and minimum and maximum values were 126-137 mmol L^{-1}, respectively. For K^+, a standard deviation of 0.24 was recorded, a coefficient variation of 5.96% and the value registered with the highest frequency was 4.1 mmol L^{-1}. Regarding Ca^{2+}, we observed a standard deviation (0.04 mmol L^{-1}), together with a coefficient variation of 3.17%, the minimum and maximum values registered in the data distribution were 1.28-1.47 mmol L^{-1}, respectively (Table 2).

A coefficient variation for the hematocrit variable was calculated at 6.43%, the mode observed in the data distribution was 43%. The rectal temperature coefficient variation was 2.26°C, the value registered with the highest frequency in the data distribution was 38.5°C and the data range fluctuated between 36-38.5°C (Table 2).

Short hair English vs. Duncan-Hartley: The comparison between clinical and laboratory variables reveals that the CO_2 and some traits such as the Ca^{2+}, hematocrit tCO_2 and

Table 1: Blood gas, electrolytes, substrates, hematocrit values and parameters calculated in the total blood of short hair English guinea pigs under anesthesia with 50 mg kg^{-1} of ketamine and 3 mg kg^{-1} of xylazine

Parameters	SD	Variation coefficient (%)	Mode	Min.	Max.
pH	0.06	0.89	7.48	7.28	7.55
PCO_2 (mmHg)	4.99	14.57	31.0	28.0	42.0
PO_2 (mmHg)	19.42	40.67	70.0	18.0	70.0
Na^+ (mmol L^{-1})	3.80	2.83	131	1250	141
K^+ (mmol L^{-1})	1.02	24.49	3.00	3.00	7.50
Ca^{2+} (mmol L^{-1})	0.21	22.12	1.23	0.52	1.28
Glucose (mg dL^{-1})	38.11	28.31	64.0	64.0	1900
Lactate (mg dL^{-1})	1.14	43.00	1.60	1.00	5.00
Hematocrit (%)	3.67	10.69	35.0	27.0	40.0
Rectal temperature (°C)	0.59	1.59	37.5	36.7	38.7
HCO_3^-	4.51	18.31	22.6	14.6	32.0
tCO_2	4.61	17.92	22.5	15.6	33.3
SO_2c	24.57	32.82	94.0	32.0	96.0
THbc	1.14	10.72	10.9	8.4.0	12.4

Table 2: Blood gas, electrolytes, substrates, hematocrit values and parameters calculated in the total blood of the Duncan-Hartley guinea pigs under anesthesia with 50 mg kg^{-1} of ketamine and 3 mg kg^{-1} of xylazine

Parameters	SD	Variation coefficient (%)	Mode	Min.	Max.
pH	0.04	0.60	7.39	7.38	7.53
PCO_2 (mmHg)	2.71	7.09	40.0	33.0	44.0
PO_2 (mmHg)	9.99	26.43	46.0	25.0	52.0
Na^+ (mmol L^{-1})	2.60	1.95	132	126	137
K^+ (mmol L^{-1})	0.24	5.96	4.10	3.60	4.60
Ca^{2+} (mmol L^{-1})	0.04	3.17	1.36	1.28	1.47
Glucose (mg dL^{-1})	29.95	20.84	98.0	98.0	211
Lactate (mg dL^{-1})	1.89	10.84	0.70	0.30	6.60
Hematocrit (%)	2.81	6.43	43.0	38.0	49.0
Rectal temperature (°C)	0.85	2.26	38.5	36.0	38.5
HCO_3^-	3.42	12.59	21.3	21.3	33.4
tCO_2	3.47	12.25	24.5	22.4	34.6
SO_2c	14.83	20.80	54.0	49.0	90.0
THbc	0.88	6.52	13.3	11.8	15.2

Table 3: Effect of the guinea pig strain on blood gas, electrolytes, substrates, hematocrit values and parameters calculated in the total blood of the guinea pigs (short hair English vs. Duncan-Hartley) under anesthesia with 50 mg kg^{-1} of ketamine and 3 mg kg^{-1} of xylazine

Parameters	Group 1 (n = 20) (Short hair English)	Group 2 (n = 20) (Duncan-Hartley)	t-student test (α)	Addition of ranges Wilcoxon (α)
pH	7.46±0.01	7.450±0.01	0.7831	0.4006
PCO_2 (mmHg)	34.25±1.11	38.30±0.600	0.0034	0.0135
PO_2 (mmHg)	47.75±4.34	37.80±2.230	0.0510	0.1132
Na^+ (mmol L^{-1})	133.95±0.85	133.35±0.580	0.5643	0.6926
K^+ (mmol L^{-1})	4.17±0.22	4.16±0.050	0.9498	0.7861
Ca^{2+} (mmol L^{-1})	0.97±0.04	1.37±0.009	0.0001	0.0001
Glucose (mg dL^{-1})	134.60±8.52	143.70±6.690	0.4068	0.6553
Lactate (mg dL^{-1})	2.66±0.25	1.86±0.420	0.1189	0.3333
Hematocrit (%)	34.35±0.82	43.70±0.620	0.0001	0.0001
Rectal temperature (°C)	37.60±0.13	37.61±0.190	0.9660	0.9243
HCO_3^-	24.66±1.01	27.22±0.760	0.0516	0.0639
tCO_2	25.73±1.03	28.39±0.770	0.0473	0.0639
SO_2c	74.85±5.49	71.30±3.310	0.5841	0.1552
THbc	10.66±0.25	13.55±0.190	0.0001	0.0001

Values are expressed as mean±SD

THbc showed the most important variation in different strains of guinea pigs under anesthesia (3 mg kg^{-1} of xylazine and 50 mg kg^{-1} of ketamine). The PCO_2 value was 4.05 mmHg greater in Duncan-Hartley guinea pigs, compared to the short hair English guinea pigs. Regarding calcium, we observed a difference of 0.4 mmol L^{-1}, the result was higher in the Duncan-Hartley strain. The hematocrit values for the Duncan-Hartley strain resulted as 9.35% greater when compared to the short hair English strain. For the tCO_2 parameter there was a significant difference between strains, resulting 3.64 mmol L^{-1} greater in the Duncan-Hartley, compared to the Short Hair English strain. Finally, a value of 2.89 mmol L^{-1} was identified for the THbc variable in the Duncan-Hartley strain resulting significantly higher in the Short Hair English strain (Table 3).

DISCUSSION

Blood pH, we observed little variability in both strains used in the present study, the range of this variable can be considered reliable for future investigations (ya que esta variable permanence estable a la combinacion de ketamina/xylazina). The results obtained in this study agree with the normal reported values (pH: 7.43±0.02) for Duncan-Hartley guinea pigs under xylazine-ketamine anesthesia combination (0.15-25 mg kg^{-1}) (Hart *et al*., 1984). The results also agree with reported values (pH: 7.29-7.43) for Duncan-Hartley guinea pigs under xylazine-ketamine anesthesia (5-20 mg kg^{-1}) (Jacobson, 2001) and normal values reported (7.414±0.052) for pigmented guinea pigs with the same anesthesia combination (Lall and Buckner, 1976). The results obtained are an indication of the ability for a species to maintain acid base balance and imperceptible anesthetic on pH. Blood pH <7.0 (>100 nmol L^{-1} of H^+) or >7.7 (<20 nmol L^{-1} of H^+) may cause death, for which blood pH is regulated inside the physiological limits como ha sido observado en cobayos y equinos (DeRouchey *et al*., 2003; Mutis *et al*., 2004). Normally, values below 7.32 indicate intracellular acidosis reflecting inadequate liberation of oxygen (Leach and Treacher, 1998). Schwenke and Cragg (2004), indicate that the pH value is not affected by administering xylazine-ketamine (5-20 mg kg^{-1}). Lactate is metabolized by the liver and kidney through oxidant and non oxidant routes, mainly glycogenolysis (Deshpande and Ward-Platt, 1997).

Regarding PO_2 values, there was no difference between strains; however, the range of data in the short hair English strain had more wide results due to a greater dispersion of data. The range of values obtained for PO_2 in the Duncan-Hartley strain was similar to the normal values reported (34.5-75.93 mmHg) for Duncan-Hartley guinea pigs anesthetized with xylazine-ketamine by Jacobson (2001). However, the results were different from what was reported by other investigators, for example Schwenke and Cragg (2004), reported effects of xylazine-ketamine on some cardiovascular values. These investigators mention that the PO_2 values in Duncan-Hartley anesthetized guinea pigs was 79±2 mmHg. Hart *et al*. (1984), indicate that 81±13 mmHg could be considered as a normal value for xylazine-ketamine anesthetized guinea pigs. Brown *et al*. (1989), reported the highest values that we have found in literature on pigmented guinea pigs anesthetized with xylazine-ketamine (80.0±8.9 mmHg).

According to Schwenke and Cragg (2004), the PO_2 value for guinea pigs without anesthesia is 98±2 mmHg. These investigators mention that the use of combined xylazine-ketamine decreases PO_2 by 17%, due to diminishing respiratory frequency. It is well known that alveolar hyperventilation is reflected by falling PO_2 accompanied by an increase in PCO_2 (Treacher and Leach, 1998). Anesthesia is one of the factors that reduce

breathing, resulting in diminished the supply of oxygen to organs and tissues (Brown *et al*., 1989). Xylazine can induce cardiovascular alterations, including atrioventricular blocking and diminished demand for O_2 by myocardium (Sumano and Ocampo, 2006). On the other hand, ketamine induces cardiovascular stimulation and increases oxygen consumption but in some cases causes slight respiratory depression (Prys-Roberts and Mug, 1986; Trevor and White, 2005).

Regarding CO_2 partial pressure the Duncan-Hartley strain had higher levels compared to the short hair English strain. The value reported by Hart *et al*. (1984), Duncan-Hartley strain guinea pigs anesthetized with xylazine-ketamine for this variable was 34.1±3 mmHg and is within the range of values that we reported for the same strain. Schwenke and Cragg (2004), reported a PCO_2 of 38±1 mmHg in a study carried out on Duncan-Hartley guinea pigs under the same anesthesia combination this value was considered as elevated by the investigators. Also, Brown *et al*. (1989) reported that guinea pigs anesthetized with xylazine-ketamine had a PCO_2 parameter of 39.5±6.5 mmHg as a normal value. However, Jacobson (2001) recently reported that Duncan-Hartley guinea pigs anesthetized with xylazine-ketamine in a range from 50.3-71.4 mmHg, higher than what is reported in this investigation.

Generally, the xylazine-ketamine anesthesia caused metabolic and respiratory depression in Duncan-Hartley and pigmented guinea pigs (Schwenke and Cragg, 2004). Brown *et al*. (1989) observed that the PCO_2 values tend to elevate significantly after inducing guinea pigs with this anesthesia combination. They also point out that the blood gas can only be affected or altered if the magnitude of the respiratory depression is severe as reflected by a reduction in PO_2 accompanied by an increase in PCO_2. Similarly, Jacobson (2001) observed a prolonged decrease in the respiratory rate, diminished oxygen in the blood and increase of CO_2. It is important to mention that the concentration of PCO_2 reflects balance between metabolic production of CO_2 and ventilation excretion (Brouillette and Waxman, 1997).

Regarding the range reference for Na^+ and P^+ no differences were observed between strains for which we can indicate that these values can be considered as normal in guinea pigs anesthetized with xylazine-ketamine (3-50 mg kg^{-1}). However, the calcium values observed had a difference of 0.4 mmol L^{-1} between strains, resulting greater for Duncan-Hartley guinea pigs. The elevated levels of calcium could be related to a probable increase in the parathyroid hormone. Increase in this hormone initiates a skeletal calcium mobilization; this way an increase in the calcium levels could be involved in the defense mechanism responding to stress (Starkov *et al*., 2004).

In this study, we observed slight unpredictable results in the rectal temperature of the short hair English and Duncan-Hartley guinea pigs; however, the value ranges were less in the Duncan-Hartley strain. These results agree with data reported by Jacobson (2001) regarding Duncan-Hartley guinea pigs anesthetized with xylazine-ketamine, where a range of 36-38°C rectal temperature was observed.

The value ranges reported for the HCO_3^- parameters in Duncan-Hartley guinea pigs was similar to the range obtained previously by Jacobson (2001) in guinea pigs of the same strain and anesthetized with xylazine-ketamine, the resesrcher reported a range of 20.3-24.21 mEq L^{-1} and these results were considered as normal for the investigator. The importance of HCO_3^- is rooted in its function as a system buffer that avoids drastic changes in blood pH. When, there is an increase of acid on a corporal level, the first reaction is a chemical spring through the HCO_3^- that combines with hydrogen ions as a result of metabolism producing carbonic acid, which separates into $CO_2 + H_2O$, the CO_2 is eliminated by the respiratory system and the water serves to maintain the homeostasis in the different compartments (Guyton and Hall, 1997; Mathews *et al*., 2002). Acid-base balance requires the integration of three organic systems: liver, lungs and kidney. The liver metabolizes the proteins producing hydrogenions, the lungs eliminate the CO_2 and the kidney generates HCO_3^- (Mutis *et al*., 2004).

The hematocrit results obtained in this study agree with the normal limits reported in guinea pigs anesthetized with xylazine-ketamine (5-30 mg kg^{-1}), these varied between 37-45% according to Brown *et al*. (1989) and are maintained without significant change during the effect of the anesthesia. It is worth mentioning that in this study, the hematocrit values in the Duncan-Hartley strain were 38-49% and these differ from what was previously reported by Hart *et al*.(1984), in the Duncan-Hartley strain anesthetized with xylazine-ketamine (0.15-25 mg kg^{-1}) and were considered as normal (30±5%). The hematocrit values in Duncan-Hartley guinea pigs were statistically greater compared to the values obtained for the short hair English strain. One possible explanation could be because of a splenic-contraction and tissue hypoxia in response to the spleen liberating adrenaline because of strong stimulation, expulsing red cells into circulation and producing polyglobulism with an increase in the erythrocyte count (Mutis *et al*., 2004).

Ketamine is the only intravenous anesthesia with analgesic properties that initiates cardiovascular stimulation (Trevor and White, 2005), although in some cases, the ketamine increases cardiac output and can increase the hepatic blood flow and tissue perfusion

(Prys-Roberts and Mug, 1986). One of the adverse effects of xylazine is that it decreases the cardiac rate (Schwenke and Cragg, 2004). However, when these drugs are combined and administered to healthy guinea pigs, they induce diminished moderation of the cardiac rate (Hart *et al*., 1984; Jacobson, 2001).

We have also observed that xylazine-ketamine is a safe anesthesia and can be administered to guinea pigs due to the fact that the cardiovascular systems are satisfactorily preserved (Brown *et al*., 1989).

Briefly, we did not observe any differences in any of the electrolyte or blood gas values in the two guinea pigs strains used con exception de las variables Ca^{2+} y la PO_2 cuyos valores fueron muy bajos. However, we can confirm that the pigmented short hair English strain showed the most favorable response regarding the PCO_2, Ca^{2+} and hematocrit values when they were submitted to chemical restraint with the xylazine-ketamine combination.

It is important to point out that the blood gas, electrolyte, substrate, hematocrit levels and other parameters calculated in the anesthetized guinea pigs blood must be maintained between the normal limits when they are under the effect of the anesthesia in order to maintain cardiovascular homeostasis and the physiological conditions of the animal under study.

The reference standard for metabolic variables and blood-gas analysis in guinea pigs anesthetized with xylazine-ketamine, showed in the present study, gives the investigator a panoramic view of the physiological conditions during surgery of guinea pigs submitted to various investigations, circumventing guinea pig suffering and favoring the welfare of the animal following the lines of the 3 R's philosophy (replacement, reduction and refinement).

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