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Acid-base Disturbance and Electrolyte Alteration in Non-descript Goats Affected with Ruminal Lactic Acidosis

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ABSTRACT

Background: The aim of these study to evaluate the changes in acid-base balance in blood during ruminal lactic acidosis in goats. The study was carried out at Madras Veterinary College Teaching Hospital, Large Animal Clinics Out -Patient Medicine Unit, Chennai on twelve non-descript goats. Goats having ruminal lactic acidosis with a history of accidental ingestion of raw rice, roti and wheat were selected for the study. The affected goats were appeared the symptoms of respiratory distress, bloated abdomen, foamy material comes out from mouth and diarrhoea.

Methods: Blood samples were collected in heparinized coated syringe for analysis of electrolyte profile and acid -base parameters analysis by using the portable automatic acid-base analyser Epoc Blood-gas Analyser System to evaluate the acid-base status and blood gases in the blood of ruminal lactic acidosis affected goats. Rumen fluid was collected by using oro-ruminal tube. Electrocardiographic examination was performed in standing position without any sedation using a bipolar apex-base lead system.

Result: Microscopic examination of rumen fluid revealed no protozoal movement. Highly significant decrease in blood pH, PvO_2 value, $cHCO_3$- value and BE (ecf) value in goats affected with acidosis when compared with the healthy control group. A highly significant increase in $PvCO_2$ value, Anion Gap and blood lactate was observed in acidosis goats when compared to control. A highly significant increase in the haemoglobin levels and RBC level was observed in acidotic goats when compared to healthy goats. There was significant increase of BUN and creatinine value in acidosis goat. Electrolyte examination appears hypocalcemia, hyponatremia, hypochloremia and hypokalemia in acidosis goat when compared with healthy control group. ECG observed sinus tachycardia and characterized by increased heart rate, decreased P-R interval, significant changes in the ST and PR segment, increased P and T wave amplitudes and decreased regular R-R intervals.

Key words: Acid base analysis, Acidosis, ECG, Non-descript goat, Rumen fluid.

INTRODUCTION

Goats are said to be poor man's cow. Goats have the widest ecological range and have been poor people's most reliable livelihood resource. Traditionally goats have served as a source of livelihood and financial security to large sections of society. Goats plays a significant role in providing supplementary income and livelihood to millions of landless poor farmers and laborers of rural India. This small ruminant farm animal has tremendous potential for upliftment of rural and urban prosperity. The occurrence of diseases in goats causes heavy economic losses in terms of livestock health and production. The carbohydrate engorgement is one of the most commonly encountered gastrointestinal disorders of the goats (Basak *et al.,* 1993). Ruminal lactic acidosis is a common problem, which occurs when ruminants consume excessive amount of readily fermentable carbohydrate rich feed and after ingestion the ruminal environment get altered and gram-positive bacteria like *Streptococcus bovis, Lactobacillus proliferate*, leads to the production of large quantities of lactic acid in the rumen (Blood *et al.,* 1983). In acidosis, it is very important to know the changes in biochemical parameters (Bhagavantappa, 2017). A small quantity of carbohydrate can cause ruminal acidosis in goats and mortality rate can be very high in acute and per-acute cases, which may be due to serious damage inflicted on vital organs by the lactic acid, severe metabolic acidosis, endotoxins, histamines and the functional disturbances caused by low pH, dehydration, hypotension and biochemical alteration. Blood gas analysis was valuable tool to diagnose of ruminal lactic acidosis because it provides a good assessment of acidosis and is also less invasive than rumen pH analysis.

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MATERIALS AND METHODS

The study was conducted at the Large Animal Clinics Out-patient Medicine Unit, Madras Veterinary College Teaching Hospital, TANUVAS, Chennai for a period from December

2022 to September, 2023. Goats of different age and sex, non-descript breed having the history of ingestion of excess highly fermentable carbohydrate rich diet were screened. In this study, 12 goats having rumen liquor pH below 5 and 6 goats having rumen liquor pH 7 were selected. 6 numbers of apparently healthy goats were kept as control animals.

Acid- base and electrolyte analysis

A complete acid- base balance parameters and electrolytic profile were analysed using portable automatic acid-base analyse Epoc Blood-gas Analyser System to evaluate the acid-base status and blood gases in the heparinized blood samples. Parameters under study were blood pH, partial pressure of carbon dioxide (pCO_2), partial pressure of oxygen (pO2), bicarbonate concentration ($cHCO^{3-}$), base excess (BE), A Gap, sodium (Na^+), potassium (K^+), calcium (Ca^{2+}), chloride (Cl-), glucose (Glu), lactate (Lac), BUN, creatinine and urea.

Haematology examination

Haematological examinations were performed to estimate haemoglobin, PCV, Red blood cell, White blood cell, Neutrophil, Lymphocyte, Monocyte and Eosinophil.

Rumen fluid analysis

Rumen fluid was collected using oro-ruminal tube as per the technique described by Petrovski (2017). A probang gag was placed in the oral cavity for restraining and to prevent damage to teeth. The stomach tube was passed into the rumen by inserting the tube dorsal to the tongue. Ruminal contents were collected by using suction pump. The collected sample was used for analysis.

Electrocardiographic examination

Electrocardiographic examination was performed in standing position without any sedation using a bipolar apex-base lead system. The positive electrode (left arm) was placed over the cardiac apex in fifth left intercostal space at level of elbow, negative electrode (right arm) was placed in left jugular furrow at lower one third, earth electrode (right limb) was placed at 7th dorsal spine as recommended by Radostits *et al.,* (2007). ECG tracings were obtained in Lead -II with a multichannel electrocardiographic machine (Model-Cardiart GenX3, manufactured by BPL, India) with paper speed of 25 mm/s and calibration of 10 mm equal to 1 mV.

RESULTS AND DISCUSSION

Clinical sign

The acidosis goats were the symptoms of anorexia, respiratory distress, bloated abdomen, profuse watery and foul-smelling diarrhoea, lateral recumbency, foamy material comes out from mouth and dehydrated due to movement of excessive quantities of fluid into the rumen, similar finding was reported by Constable *et al.* (2017). Clinical examination reveals all animals having fluid splashing abdominal sound due to accumulation of large quantity of fluid in the rumen (Saravanan *et al.,* 2021). Absence of ruminal motility, tachycardia due to endotoxaemia, increased respiratory rate, prolonged skin tenting and capillary refill times (Table 1) were the clinical signs observed, findings are in concurrence with the observations of Alam *et al.* (2014); Elnady *et al.* (2019) and Koondhar *et al.* (2020).

Rumen fluid examination

The colour of the rumen fluid in all acidosis goats was milky white and the healthy goats was brownish to greenish. The consistency of rumen fluid was viscous in control group and watery in acidosis goats. The odour of the rumen fluid in acidotic goats were sour and aromatic in control animals. The findings were in accordance with Kala *et al.* (2021); Tufani *et al.* (2013). No protozoal motility with absence of iodophilic activity and presence of gram-positive bacteria were observed in all acidosis cases. Iodophilic activity of rumen protozoa was totally absent, finding supports the observation of Shah *et al.* (2013), which might be due to improper utilization and storage of glycogen by the rumen protozoa. Rumen liquor smear of acidotic goats revealed predominant of gram-positive bacteria (Brahma *et al.,* 2020).

The mean and SE values of rumen pH of goats with acidosis and control were 6.50±0.22 and 4.67±0.14. A highly significant decrease ($P< 0.01$) in the ruminal pH was

Table 1: Vital signs in goats with ruminal lactic acidosis.

Parameters	Control (Mean±SE)	Acidosis (Mean±SE)	t-value
Temperature (^oF)	102.70±0.16	102.20±0.43	0.88NS
Heart rate (Rate/min)	75.83±1.42	130.4±1.94	18.52**
Pulse rate (Rate/min)	80.33±2.49	60.17±3.23	4.08**
Respiration rate (Rate/min)	24.67±1.09	33.00±2.06	2.73*
Capillary refill time (/sec)	1.17±0.17	3.17±0.21	6.28**
Skin tent test (/sec)	1.50±0.22	2.17±0.17	2.35*

Table 2: Rumen fluid analysis in control and acidosis goats.

Parameters	Control (n=6)	Acidosis (n=12)	t- value
pH	6.50±0.22	4.67±0.14	7.19**
SAT (min.)	5.67±0.33	13.67±0.41	12.55**
MBRT (min.)	4.67±0.21	11.50±0.77	6.09**

observed in the affected group when compared to control group. The decrease in ruminal pH might be due to faster fermentation of rapidly fermentable carbohydrates by amylolytic bacteria leading to production of excess quantities of lactic acid (Hajikolaei *et al.,* 2006; Radostitis *et al.,* 2007, Gonzalez *et al.,* 2012 and Pradeep *et al.,* 2007). The means and SE values of Methylene Blue Reduction test (MBRT) time to decolorize the dye in control and acidosis group (Table 2) were 4.67±0.21 min. and 11.50± 0.77 minutes. A highly significant increase in the time taken by the rumen fluid to decolorize the dye was observed in acidosis group when compared to control group, which was in agreement with the reports of Shah *et al.,* (2013) and Petrovski, (2017), which could be due to destruction of normal micro flora and a shift in their pattern from predominantly gram negative to amylolytic gram positive nature (Shah *et al.,* 2013).

Venous blood gas analysis

The mean and S.E. value of blood pH in control and acidosis animals (Table 3) was 7.41±0.01 and 7.13±0.08. Highly significant decrease in blood pH in goats with acidosis. In acidosis the increased VFA and lactate in rumen resulted in lower pH followed by absorption of lactate in to the systemic circulation causing a reduction in blood pH (Snyder and Credille, 2017).

The mean and S.E. values of $PvCO_2$ (mm Hg) in control and acidosis goats was 39.38±1.61 and 43.55±0.88. A highly significant increase in $PvCO_2$ value was observed in acidosis goats when compared to control (Morgante *et al.,* 2009; Gianesella *et al.,* 2010).

The mean and S.E. values of PvO_2 (mm Hg) in control and acidosis goats were 40.27±1.47 and 34.62±1.71. A highly significant decrease in PvO_2 value was observed in acidosis goats when compared to control. The decrease in the values of oxygenation can be attributed to an increase in the anaerobic metabolism and consequently an increase in oxygen consumption (Morgante *et al.,* 2009 and Gianesella *et al.,* 2010).

The mean and S.E. values of $cHCO_3$- (mmol/L) in control and acidosis goats were 23.92±0.30 and 14.25± 2.33. A highly significant decrease of $cHCO_3$- value was observed in acidosis goats when compared to control. Reduction in bicarbonate level was observed in acidosis group and this was mainly due to excessive accumulation of acids which exceeds the buffering capacity of bicarbonate (Owens *et al.,* 1998, Snyder and Credille, 2017).

The mean and S.E. value of BE (ecf) (mmol/L) in control and acidosis goats were -2.73±0.07 and -8.26±4.45. A highly significant decrease ($P<0.01$) in BE (ecf) value was observed in acidosis goats when compared to control. The excessive acids in acidosis resulted in reduction in base

Table 3: Venous blood gas analysis in control and acidosis goats.

Parameters	Control (Mean±SE)	Acidosis (Mean±SE)	t- value
Blood pH	7.41±0.01	7.13±0.08	2.60**
$PvCO_2$ (mm Hg)	39.38±1.61	43.55±0.88	2.49*
PvO_2 (mm Hg)	40.27±1.47	34.62±1.71	2.13*
Lactate (mmol/L)	0.71±0.04	5.92±1.14	3.19**
$CHCO_3$- (mmol/L)	23.92±0.30	14.25±2.34	2.88**
BE (ecf) (mmol/L)	-2.73±0.07	-13.33±3.09	2.38**
A gap (mmol/L)	15.00±1.00	21.92±0.80	5.16**

Table 4: Haematology and electrolyte analysis in control and acidosis goats.

Parameters	Control (Mean±SE)	Acidosis (Mean±SE)	t-value
Haemoglobin (g/dL)	9.78±0.33	13.26±0.28	7.50**
PCV (%)	33.68±1.38	39.27±0.35	5.21**
RBC (m/cmm)	15.32±1.31	23.06±0.93	4.81**
WBC (/cmm)	11000.00±292.1	11533.00±223.00	1.41NS
Neutrophil (%)	36.00±0.86	47.58±6.78	1.187NS
Lymphocyte (%)	61.83±3.16	50.92±6.09	1.212NS
Monocyte (%)	2.33±0.33	3.50±0.48	1.593NS
Glucose (mg/dL)	87.50±5.04	138.17±28.72	1.224NS
BUN (mg/dL)	17.33±2.11	24.53±1.58	2.67*
Creatinine (mg/dL)	0.92±0.10	2.08±0.22	3.65**
Urea (mmol/L)	7.70±0.93	8.97±1.72	.497NS
Ca++(mmol/L)	2.55±0.09	0.91±0.14	7.539**
Na+ (mmol/L)	143.00±2.14	132.08±3.01	2.394*
Cl- (mmol/L)	107.30±1.36	100.30±1.13	3.74**
K+ (mmol/L)	4.16±0.19	2.95±0.13	5.44**

excess (BE) in blood, similar to the findings reported by (Gianziella *et al.,* 2010 and Snyder and Credille, 2017).

The mean and S.E. value of Anion Gap in control and acidosis were 15.00±1.00 and 21.92±0.80. A highly significant increase (P<0.01) in AGap value was observed in acidosis group when compared to control group. Elevation in Anion gap was observed in goats with acidosis, these findings were in concurrence with Snyder and Credille (2017). Anion gap is the difference between strong cations and anions and was found to be elevated in goat kids with floppy kid syndrome by D - lactic acidosis (Bleul *et al.,* 2006). The higher anion gap is due to accumulation of acids or reduction of bicarbonate (Russel and Rousel, 2007).

The mean and S.E value of blood lactate in control and acidosis animals were 0.48±0.04 and 6.16±1.05. A significant increase (P<0.01) in blood lactate value was observed in acidosis group as compared to control group. The mean±SE values of lactic acid was found elevated and these might be due to excess accumulation of lactic acid in rumen which subsequently get absorbed into blood (Hajikolaei *et al.,* 2006). In animals with acidosis the production of lactate exceeds the absorption capacity resulting in reduction in rumen pH and further absorption into the systemic circulation. The L lactate is metabolized efficiently whereas D lactate is not and lactic acidosis is characterised by accumulation of D lactate rather than L lactate (Snyder and Credille, 2017).

Haematology and electrolyte changes analysis

A highly significant increase in the haemoglobin levels was observed in acidotic goats when compared to healthy goats (Table 4). This finding was in agreement with the findings of Sharma and Nath (2005), Gupta *et al.,* (2012) and Thorat *et al.,* 2021. Ibrahim, (2016), who recorded the rise in haemoglobin levels might be due to haemoconcentration caused by dehydration and drawing of systemic fluid into the rumen. In acidosis, there was a highly significant rise in packed cell volume when compared with control group, which are in accordance with the findings of Shihabudeen *et al.,* 2003; Sharma and Nath, (2005).

In the present study, the Mean±SE values of RBC in acidosis goats was found to be significantly increased which was in accordance with the observations made by Shah *et al.* (2013) and Zein-Eldin *et al.* (2014).

In acidosis, the BUN value was found to be significantly increased which might be due to dehydration, haemoconcentration, anuria and catabolism with body toxaemia (Karale, 2012). A highly significant difference was observed between groups and a highly significant increase in the creatinine values in acidosis goats. Karale, (2012) reported that increased creatinine level in acidosis goats might be due to state of dehydration and haemo-concentration as occurred in acidosis and activation of compensatory mechanism in the body.

Hypocalcemia in acidosis might be due to temporary malabsorption of calcium due to damaged mucosa of intestine (Radostits *et al.,* 2007). Decreased serum sodium accompanied with ruminal lactic acidosis may be due to shift of electrolytes by osmolarity from blood to hypertonic rumen or due to their losses (Na^+ and Cl^-) or due to diarrhea (Jorg and Enemark, 2008). Decrease in serum chloride accompanied with ruminal lactic acidosis might be due to shift of electrolytes by osmolarity from blood to hypertonic rumen or due to their losses (Na^+ and Cl^-) or due to diarrhoea (Jorg and Enemark, 2008).

In acidosis, hypokalemia might be due to retention of sodium and excess excretion of potassium by the kidney (Gupta, 2012; Saravanam, 2021). Shah *et al.* (2013), reported that hypokalemia in the acidotic sheep might be due to the excretion of K^+ through the kidney as K^+ are

Table 5: Electrocardiography examination in control and acidosis goats.

Parameters	Control (Mean±SE)	Acidosis (Mean±SE)	t-value
P-R (Second)	0.13±0.01	0.10±0.01	4.00**
P amplitude (mV)	0.12±0.02	0.23±0.01	4.94**
T amplitude (mV)	0.32±0.02	0.40±0.02	2.55*
R-R interval (Second)	0.78±0.03	0.50±0.02	6.89**
ST interval (Second)	0.30±0.01	0.22±0.01	4.53**

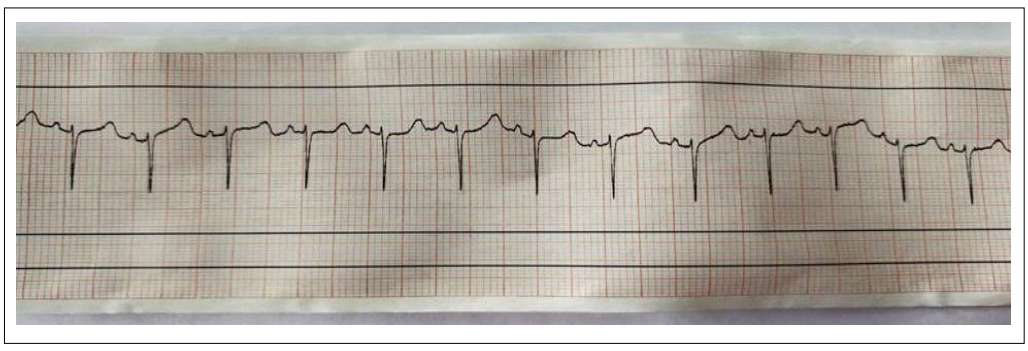

Fig 1: ECG changes in ruminal lactic acidosis goat.

exchange for reabsorption of Na+ probably under the influence of increased aldosterone activity.

ECG revealed increased heart rate (140-150 bpm), decreased P-R interval (0.10±0.01sec), increased P amplitude (0.23±0.01 mV) and decreased T amplitude (0.40 ±0.02 mV), decreased regular R-R interval (0.50±0.02 sec), decreased ST interval (0.22±0.01 sec) as compared to control group (Table 5 and Fig 1.) suggesting sinus tachycardia in acidosis goats. Similar changes in acidosis goats reported by Dehkordi *et al.,* (2011). An increase in T wave amplitude could be attributed to metabolic acidosis. It appears that ruminal acidosis accelerated pacemaker activity in the heart, thus increasing heart rate, but had no significant effect on the time course of the spread of the action potential through the ventricles. The decline in the PR interval may be due to a rapid propagation of the action potential through the ventricles or to rapid transmission of the action potential through the AV node.

Animal was treated with Inj. Sodium bicarb 7.5% @ 1 g/ kg body weight, Inj. Normal Saline 10 ml/ kg body weight IV, Inj. Tribivet 0.5 mg/kg body weight IV, Inj. Chlorophenaramine maleate 0.5 mg/kg body weight IM, Rumentas bolus 1bolus bid orally daily for 3 days and bolus sulpha dimidine @1 bolus/50 kg body weight. Administration of intravenous Sodium bicarbonate neutralized the lactic acid production inside the rumen to prevent chemical ruminitis and to restore normal ruminal pH (Arora *et al.,* 2011; Karale, 2012). Vitamin B Complex injection (Tribivet) as a source of thiamine administered by IV to restores the function of the cells and tissues by replenishing thiamine deficiency but also promotes metabolism of excess lactic acid thereby reducing acidosis (Bashir *et al.,* 2015). Antihistaminic drug Chlorophenaremine maleate has reduced the rumen and blood histamine level. Rumenotoric drug (bolus Rumentas) was given to restore rumen motility and appetite (Tufani *et al.,* 2013). All animal was recovered after 3rd day of treatment.

CONCLUSION

Ruminal lactic acidosis is a common acid base abnormality of goats. Acid base analysis revealed low blood pH, bicarbonate level, base excess and increased anion gap and blood lactate level. Microscopic examination of rumen fluid revealed no protozoal movement. ECG observed sinus tachycardia and characterized by increased heart rate, decreased P-R interval, significant changes in the ST and PR segment, increased P and T wave amplitudes and decreased regular R-R intervals. Haematological examination revealed increased haemoglobin and PCV values. Electrolyte examination appears hypocalcemia, hyponatremia, hypochloremia and hypokalemia.

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Conflict of interest

All authors declare that they have no conflict of interest.

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