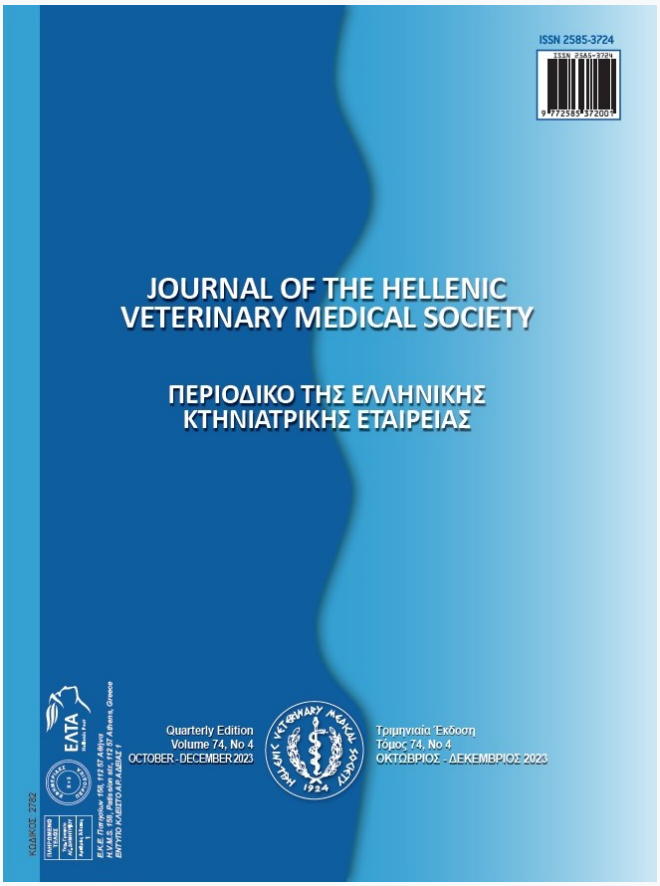
Journal of the Hellenic Veterinary Medical Society

Vol 75, No 1 (2024)




# Effect of Fluid Therapy and Oxygen Application on Venous Blood Parameters of Diarrheic Calves with Hyperkalemia

*M Özbek, C Özkan, Y Altan*

doi: 10.12681/jhvms.30370



**To cite this article:**

Özbek, M., Özkan, C., & Altan, Y. (2024). Effect of Fluid Therapy and Oxygen Application on Venous Blood Parameters of Diarrheic Calves with Hyperkalemia. *Journal of the Hellenic Veterinary Medical Society*, *75*(1), 6757–6764. https://doi.org/10.12681/jhvms.30370

J HELLENIC VET MED SOC 2024, 75 (1): 6757-6764
ΠΕΚΕ 2024, 75 (1): 6757-6764

Research article
Ερευνητικό άρθρο

# Effect of Fluid Therapy and Oxygen Application on Venous Blood Parameters of Diarrheic Calves with Hyperkalemia

**M. Özbek[1*], C. Özkan[2], Y. Altan[2]**

[1]*Afyon Kocatepe University, Bayat Vocational School, Department of Laborant and Veterinary Health, 03780, Afyon, Turkey*

[2]*Van Yuzuncu Yil University, Faculty of Veterinary Medicine, Department of Internal Medicine, 65080, Van, Turkey*

**ABSTRACT:** The purpose of this study was to evaluate the effect of oxygen therapy on clinical, hematological, biochemical and venous blood gases in diarrheic calves with hyperkalemia in addition to routine diarrhea and fluid-electrolyte therapy. Animal material consisted of 20 diarrheic and hyperkalemic calves, of different ages. Diarrheic calves with serum potassium levels greater than 6 mmol/L were included in the study following the clinical examination and analysis results. The calves were divided into two groups. Calves in the 1st group (n=10) received routine diarrhea and fluid-electrolyte treatment and calves in the 2nd group (n=10) received routine diarrhea and fluid-electrolyte treatment as well as oxygen applications by mask. Blood samples were taken from the animals for blood gas, hematological and biochemical analyses. The decrease in heart rate and respiratory rate was more significant in the 2nd group when compared to the 1st group. When statistically comparing the same time periods of both groups, heart rates were lower in the oxygen applied group and this decrease was statistically significant ($p < 0.05$). In the 2nd group; decrease in WBC, Lym, RBC, Hct%, Hb, MCH, MCHC and MCV levels and increase in Neu and THR levels were statistically significant ($p < 0.05$). Increase in pH, $pO_2$, $sO_2$, Na, Cl, $cHCO_3$ and decrease in $pCO_2$, K, Lac, cBaseEcf and AnionGap were detected. When comparing the same time period of 1st and 2nd groups, statistically significant differences ($p < 0.05$) were determined on the 5th hour in K, on the 24th hour in pH and $pO_2$ values. Particularly in the oxygen applied group; there were statistically significant alterations in pH, $pCO_2$, $pO_2$, $sO_2$, K and Lac ($p < 0.05$). Among biochemical parameters; decrease in LDH and TP in the 2nd group, and decrease in TP and ALB in the 1st group were found to be statistically significant ($p < 0.05$). As a result, oxygen administration in addition to routine diarrhea treatment is thought to have positive effects on pH, $pO_2$, $pCO_2$, $sO_2$and K. Based on the results obtained in this study, it was concluded that oxygen therapy would be beneficial for calves with diarrhea and hyperkalemia.

**Keywords:** Calves; Diarrhea; Hyperkalemia; Oxygen; Potassium

*Corresponding Author:*
Mustafa Özbek, Afyon Kocatepe University, Bayat Vocational School, Department of Laborant and Veterinary Health, 03780, Afyon, Turkey.
E-mail address: mozbek@dr.com

*Date of initial submission: 17-05-2022*
*Date of acceptance: 12-06-2023*

## INTRODUCTION

Diarrhea is a symptom of various infectious and non-infectious diseases which is characterized by frequent and loose stool. Diarrhea is common in calves particularly during the neonatal period, and can lead to mortality and growth failure which also causes significant economic losses in the cattle industry (Ozkan and Akgul, 2004; Ocal et al., 2006; Sen et al., 2013). Despite the improvements in scientific studies and treatment methods, calf diarrhearemains a challenge due to its complex etiology and high mortality rate. Nevertheless, appropriate fluid-electrolyte therapy is necessary in most cases of calf diarrhea (Ozkan and Akgul, 2004; Baser and Civelek, 2013).

In calves suffering from diarrhea, significant amounts of fluid and electrolyte losses occur and with eventual dehydration, metabolic acidosis and hyperkalemia worsen the situation (Kalinbacak, 2003). Finally, if a proper treatment is not applied, the consequences due to acute kidney failure, bicarbonate deficiency as well as metabolic acidosis and hyperkalemia lead to an inevitable death. Therefore; dehydration, electrolyte and acid-base imbalance, metabolic acidosis and hyperkalemia need to be compensated for effective treatment(Sahal, 1994; Senturk, 2001; Ozkan and Akgul, 2004; Zeybek and Civelek, 2014).

Blood gases and related parameters are useful for revealing acid-base balance and fluid-electrolyte levels in animals, and are important for the diagnosis, treatment and evaluation of the prognosis of various diseases (Nagy et al., 2002; Kurtdede, 2004; Nagy et al., 2006).In calves with diarrhea, in addition toroutine and fluid-electrolyte therapy, the need for additional supportive treatments is reported. To this end, oxygen therapy is indicated (Cambier et al., 2001).

Currently, there are numerous studies on the effect of oxygen therapy on blood gas parameters,particularly in respiratory system disorders (Wilson et al., 2006; Ersoy and Topeli, 2016). Furthermore, despite the presence of several studies concerning calf diarrhea and different therapeutic methods, there arenot enough studies associated with the application of oxygen in calf diarrhea for supportive therapy.

The purpose of this study was to evaluate the effect of oxygen therapy on clinical, hematological, biochemical and venous blood gases in diarrheic calves with hyperkalemia in addition to routine diarrhea and fluid-electrolyte therapy.

## MATERIALS AND METHODS

### Animal Material

This study was performed with permission of the Animal Experiments Local Ethics Committee, Rectorship of Van Yuzuncu Yil University (April 29th, 2021 - 2021-04/33). Animal material of this study consisted of 20 diarrheic and hyperkalemic calves, of different ages (0 - 7 days) that were brought to the clinics of Van Yuzuncu Yil University, Faculty of Veterinary Medicine, Department of Internal Medicine. Diarrheic calves with hyperkalemia and serum potassium levels greater than 6 mmol/L were included in the study following the clinical examination and analysis results.

### Clinical Examination

General examination of all diarrheic animals was performed. While performing general examinations, animals with cardiac arrhythmias were suspected of hyperkalemia, and blood samples were obtained into syringes containing heparin strips from jugular veins for blood gas analyses, and into tubes with EDTA and coagulant-free tubes for hematological and biochemical analyses, respectively. According to blood gas analyses, 20 animals with higher than 6 mmol/L potassium levels were considered hyperkalemic and included in the study. Then these animals were recorded on the individual examination form and consent from animal ownerswas received. ECG, oxygen saturation and body temperatures of the calves were monitored by a patient monitoring device (Compact 7, Medical Econet).

### Grouping animals

The calves were divided into 2 groups. The average ages of the calves in the 1$^{st}$ group was 6.29±0.94 and in the 2$^{nd}$ group, it was 5.75±0.82 (Table 1).Calves in the 1$^{st}$group (n=10) received routine diarrhea and fluid-electrolyte treatment and calves in the 2$^{nd}$group (n=10) received routine diarrhea and fluid-electrolyte treatment as well as oxygen applications by mask.

### Collecting blood samples

For venous blood gas analyses, blood samples were taken from the animals on the 0$^{th}$, 5$^{th}$ and 24$^{th}$ hours (2.5 mL) in syringes containing heparin strips. For hematological parameters, blood samples were collected from jugular veins of the animals on the 0$^{th}$and 24$^{th}$ hours into tubes with EDTA; for biochemical parameters on the 0$^{th}$, 5$^{th}$ and 24$^{th}$ hours into coagulant-free tubes. Blood gas and hematological analyses

were performed immediately after collecting blood samples, and blood samples in coagulant-free tubes were centrifuged (Rotofix 32® Hettich) at 3000 RPM for 10 mins and the sera were extracted. These sera were stored at -20 C˚ until the biochemical analyses.

From the collected samples, blood gas parameters such as pH, partial carbondioxide ($pCO_2$), partial oxygen ($pO_2$), oxygen saturation ($sO_2$), sodium (Na), potassium (K), chloride (Cl), lactate (lac), bicarbonate concentration ($cHCO_3$), base deficit (cBaseEcf), anionic gap (AnionGap) were measured in blood gas device (ABL-80® Basic). From the blood samples taken into tubes with EDTA; hematological parameters such as total white blood cell count (WBC), lymphocyte (Lym), monocyte (Mon), neutrophil (Neu), eosinophil (Eo), red blood cell (RBC), hematocrit (Hct), hemoglobin (Hb), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), thrombocyte (THR) were measured in hematology device (MS4-S®Haematology Analyzer, France). Serum biochemical parameters such as lactate dehydrogenase (LDH), total protein (Tp) and albumin (ALB) were measured in biochemistry analyser (FUJI DRI-CHEM NX500I).

**Planning treatment protocol**

For routine diarrhea treatment; sulfadoxin + trimetophrim (Bakteral® injectable solution, Topkim, Turkey, 40 + 200 mg/ml)(30 mg/kg, im, 5 days), neomycin sulfate + bismuth subcarbonate (Cesamolin® oral suspension granule, Topkim, Turkey, 40 + 400 mg/gram) (15 g/50 kg, per os, BID, 3 days), vitamin C (Tioned-C® %20 injectable solution, ICA, Turkey, 200 mg/ml) (20 mg/kg, im, 5 days), combination of vitamin A, $D_3$ and E (ADEMAX® injectable solution, ICA, Turkey, 100000 IU, 50000 IU, 50 mg) (1 mL/50 kg, im, single dose) were administered.

For intravenous fluid-electrolyte therapy; dehydration degrees and base deficits of the animals were determined and administered intravenously. For this purpose, NaCl 0.09% and $NaHCO_3$ 8.4% were used. These solutions were given to animals by using the formula below:

Fluid requirement (mL/kg)=Hct Value × (100/33.6)-100

$NaHCO_3$ (mmol/L) = Body weight (kg) × Base deficit (mmol/L) ×0.6

For oxygen therapy; oxygen was administered to the animals promptly with flow rate of 5 L/min, for 30 mins by using a face mask that was connected to a portable oxygen concentrator (HealthTime OC-5). Oxygen administrationwas ceased for 15 mins and repeated. This application was continued for 3 hrs.

**Statistical analyses**

The data obtained from the study were analysed by using SPSS for Windows 22.0 E. version, Armonk, NY: IBM Corp. A general linear model for repeated measures analysis was performed for comparing the mean values of the same groups over different time periods, and the mean values of different groups within the same time period.Significance level was taken as 5% in all performed analyses and pairwise comparisons were adjusted by the Bonferroni method.

## RESULTS

Heart rates, respiratory rates, body temperatures and mean ages, and their statistical comparisons are given in Table 1. The decrease in normal heart and respiratory values was determined in the 1st and 2nd groups in different time periods at the 24th hour. Body temperature increased to normal levels at the 24th hour in both groups and hypothermia that was present at the 0th hour was healed. The decrease in heart rate and respiratory rate was more significant in the 2nd group when compared to the 1st group. When statistically comparing the same time periods of both two groups, heart rates were lower in the oxygen applied group and this decrease was statistically significant.

Mean hematological parameters and statistical comparisons of 1st and 2nd group in the different time periods are given in Table 2. Decreases in WBC, Lym, Mon, Eo, RBC, Hct%, Hb, MCH and MCHC levels were determined at the 24th hour compared to 0th hour, and these decreases were statistically significant. Increase in Neu was also statistically significant, however alterations in THR and MCV values were not statistically significant. In the 2nd group; WBC, Lym, Mon, Eo, RBC, Hct%, Hb, MCH and MCHC levels decreased on the 24th hour when compared to 0th hour, and decreases in WBC, Lym, RBC, Hct%, Hb, MCH, MCHC and MCV levels were statistically significant. Increase in Neu and THR levels was also statistically significant. When comparing the same time period of 1st and 2nd group; there was no statistical significance on the 0th hour, however on the 24th hour, statistically significant increases in WBC, MCV and THR levels were detected.

**Table 1.** Statistical comparison of clinical findings according to groups and time periods

| Parameters | 1st group (Routine treatment) ($\bar{x} \pm S\bar{x}$) (n=10) | | | 2ndgroup (Routine treatment +Oxygen) ($\bar{x} \pm S\bar{x}$) (n=10) | | |
|---|---|---|---|---|---|---|
| | 0th hour | 5th hour | 24th hour | 0th hour | 5th hour | 24th hour |
| Heart rate (BPM) | 124.43±7.89 | 112.86±4.24 | 107.429±4.540$^{C}$ | 120.38±6.21$^{d}$ | 108.75±4.36$^{d}$ | 94.13±5.20$^{eF}$ |
| Respiratory rate (RPM) | 38.86±5.55$^{a}$ | 32.14±3.75$^{ab}$ | 27.571±2.379$^{b}$ | 37.38±4.72$^{d}$ | 30.63±3.15$^{e}$ | 24.88±2.61$^{f}$ |
| Body temperature (C°) | 36.74±0.23$^{a}$ | 37.53±0.16$^{b}$ | 38.100±0.323$^{b}$ | 35.74±0.53$^{d}$ | 37.96±0.20$^{e}$ | 38.63±0.14$^{e}$ |
| Average age (Days) | | 6.29±0.94 | | | 5.75±0.82 | |

- a, b, c: in-group comparison of 1st group according to different time periods (0th, 5th and 24th)
- d, e, f: in-group comparison of 2nd group according to different time periods (0th, 5th and 24th)
- For comparing the values of group 1 and 2 in the same time period;
- A: 0th hour, B: 5th hour, C: 24th hour

Different capital letters indicate significant differences between different groups in the same time period ($p<0.05$). Different lowercase letters indicate significant differences between the different time periods of the same group ($p < 0.05$).

**Table 2.** Comparison of hematological parameters according to groups and time periods

| Parameters | 1stGroup (Routine treatment) ($\bar{x} \pm S\bar{x}$) (n=10) | | 2ndGroup (Routine treatment + Oxygen) ($\bar{x} \pm S\bar{x}$) (n=10) | |
|---|---|---|---|---|
| | 0th hour | 24th hour | 0th hour | 24th hour |
| WBC(m/mm$^3$) | 17.31±2.04$^{a}$ | 8.49±0.97$^{bB}$ | 20.566±2.77$^{c}$ | 12.96±1.12$^{dD}$ |
| Lym(m/mm$^3$) | 4.92±0.85$^{a}$ | 2.90±0.46$^{b}$ | 5.379±0.54$^{c}$ | 3.74±0.33$^{d}$ |
| Mon(m/mm$^3$) | 1.01±0.18$^{a}$ | 0.52±0.08$^{b}$ | 1.405±0.33$^{c}$ | 0.80±0.12$^{c}$ |
| Neu(m/mm$^3$) | 9.42±2.73$^{a}$ | 12.62±3.90$^{a}$ | 12.833±2.44$^{c}$ | 15.37±2.81$^{d}$ |
| Eo(m/mm$^3$) | 0.65±0.31$^{a}$ | 0.33±0.22$^{b}$ | 1.78±1.31$^{c}$ | 0.38±0.11$^{c}$ |
| RBC(M/mm$^3$) | 9.66±0.52$^{a}$ | 8.11±0.41$^{b}$ | 9.268±0.34$^{c}$ | 7.98±0.37$^{d}$ |
| Hct(%) | 42.40±2.48$^{a}$ | 30.42±1.94$^{b}$ | 42.725±1.76$^{c}$ | 31.90±1.18$^{d}$ |
| Hb(g/dl) | 14.42±0.84$^{a}$ | 10.34±0.66$^{b}$ | 14.526±0.60$^{c}$ | 10.85±0.40$^{d}$ |
| MCV(fl) | 37.43±0.83$^{a}$ | 37.50±0.82$^{aB}$ | 37.138±1.86$^{c}$ | 35.49±1.63$^{dD}$ |
| MCH(pg) | 14.73±0.72$^{a}$ | 10.59±0.66$^{b}$ | 14.413±0.61$^{c}$ | 10.81±0.56$^{d}$ |
| MCHC(g/dl) | 35.78±4.69$^{a}$ | 25.84±3.49$^{b}$ | 39.138±1.06$^{c}$ | 30.08±1.51$^{d}$ |
| THR(m/mm$^3$) | 332.67±61.53$^{a}$ | 238.67±34.90$^{aB}$ | 303.125±34.13$^{c}$ | 456.25±51.40$^{dD}$ |

WBC: Total leucocyte count; Lym: Lymphocyte; Mon: Monocyte; Neu: Neutrophil; Eo: Eosinophil; RBC: Red blood cell count; Hct: Hematocrit; Hb: Hemoglobin; MCV: Mean corpuscular volume; MCH: Mean corpuscular hemoglobin; MCHC: Mean corpuscular hemoglobin concentration; THR: Thrombocyte

- a, b: in-group comparison of 1st group according to different time periods (0th and 24th)
- c, d: in-group comparison of 2nd group according to different time periods (0th and 24th)
- For comparing the values of group 1 and 2 in the same time period;
- A: 0th hour, B: 24th hour

Different capital letters indicate significant differences between different groups in the same time period ($p<0.05$). Different lowercase letters indicate significant differences between the different time periods of the same group ($p < 0.05$).

Mean values and statistical comparison of blood gas parameters in different time periods (0th, 5th and 24th hour) of 1st and 2nd group are given in Table 3. Increase in pH, $PO_2$, $sO_2$, Na, Cl, $cHCO_3$ and decrease in $pCO_2$, K, Lac, cBaseEcf and AnionGap were detected. When comparing the same time period of 1st and 2nd groups, there was not any statistical significance in the values of 0th hour; however statistically significant differences were determined on the 5th hour in K, on the 24th hour in pH and $pO_2$ values. Particularly in the oxygen applied group; there were statistically significant alterations in pH, $pCO_2$, $pO_2$, $sO_2$, K and Lac.

Mean values and statistical comparison of biochemical parameters belonging to 1st and 2nd groups on different time periods (0th and 24th hour) are given in Table 4. Decrease in LDH, TP, ALB and BUN levels was determined after treatment when compared to the pre-treatment values. Among these parameters; the decrease in LDH and TP in the 2nd group, and the decrease in TP and ALB in the 1st group were found

**Table 3.** Statistical comparison of blood gases according to groups and time periods

| Parameters | 1st group (Routine treatment) ($\bar{x} \pm S\bar{x}$) (n=10) | | | 2nd group (Routine treatment + Oxygen) ($\bar{x} \pm S\bar{x}$) (n=10) | | |
|---|---|---|---|---|---|---|
| | 0th hour | 5th hour | 24th hour | 0th hour | 5th hour | 24th hour |
| pH | 7.07±0.03$^{a}$ | 7.31±0.01$^{b}$ | 7.37±0.01$^{cC}$ | 6.99±0.07$^{d}$ | 7.33±0.03$^{e}$ | 7.41±0.01$^{fF}$ |
| $pCO_2$ (mmHg) | 44.36±2.68 | 39.76±1.03 | 37.74±1.70 | 43.36±1.22$^{d}$ | 37.91±1.15$^{e}$ | 33.74±1.9$^{f}$ |
| $pO_2$ (mmHg) | 18.88±1.08$^{a}$ | 26.75±1.13$^{b}$ | 28.00±1.18$^{bC}$ | 18.13±1.03$^{d}$ | 29.13±1.26$^{e}$ | 34.63±0.89$^{fF}$ |
| $sO_2$ (%) | 29.10±6.34$^{a}$ | 50.56±2.44$^{b}$ | 51.78±2.99$^{b}$ | 26.35±4.38$^{d}$ | 52.04±3.75$^{e}$ | 49.38±7.63$^{e}$ |
| Na (mmol/L) | 132.00±2.63$^{a}$ | 137.25±1.59$^{b}$ | 140.88±1.94$^{b}$ | 131.38±3.38$^{d}$ | 135.38±4.28$^{d}$ | 140.25±4.20$^{ef}$ |
| K (mmol/L) | 7.56±0.38$^{a}$ | 5.43±0.31$^{bB}$ | 4.59±0.27$^{b}$ | 8.04±0.32$^{d}$ | 6.11±0.20$^{eE}$ | 4.25±0.10$^{f}$ |
| Cl (mmol/L) | 92.50±2.04$^{a}$ | 96.88±2.75$^{b}$ | 100.13±1.65$^{b}$ | 92.88±4.45$^{d}$ | 95.75±5.09$^{d}$ | 98.88±4.92$^{ef}$ |
| Lac (mmol/L) | 4.78±0.68$^{a}$ | 3.36±0.43$^{ac}$ | 2.45±0.42$^{bc}$ | 5.98±0.85$^{d}$ | 4.65±0.82$^{e}$ | 2.54±0.55$^{f}$ |
| $cHCO_3$ (mmol/L) | 14.80±1.92$^{a}$ | 20.95±1.68$^{b}$ | 21.44±1.73$^{b}$ | 11.35±1.97$^{d}$ | 18.50±2.32$^{e}$ | 19.81±2.85$^{e}$ |
| cBaseEcf (mmol/L) | -12.65±2.44$^{a}$ | -3.89±1.91$^{b}$ | -3.34±2.03$^{b}$ | -17.54±2.61$^{d}$ | -6.69±2.90$^{e}$ | -4.86±3.38$^{e}$ |
| AnionGap | 32.17±1.61 | 26.31±1.82 | 27.31±1.58 | 35.19±1.21$^{d}$ | 28.10±2.03$^{e}$ | 27.38±2.90$^{e}$ |

pH: Power of hydrogen; $pCO_2$;Partial carbondioxide amount; $pO_2$: Partial oxygen amount; $sO_2$:Oxygen saturation; Na: Sodium; K: Potassium; Cl: Chloride; Lac: Lactate; $cHCO_3$: Bicarbonate concentration; cBaseEcf: Extracellular base deficit
- a, b, c: in-group comparison of 1st group according to different time periods (0th, 5th and 24th)
- d, e, f: in-group comparison of 2nd group according to different time periods (0th, 5th and 24th)
- For comparing the values of group 1 and 2 in the same time period;
- A: 0th hour, B: 5th hour, C: 24th hour
Different capital letters indicate significant differences between different groups in the same time period ($p<0.05$). Different lowercase letters indicate significant differences between the different time periods of the same group ($p < 0.05$).

**Table 4.** Statistical comparison of biochemical parameters according to groups and time periods

| Parameters | 1st group (Routine treatment) ($\bar{x} \pm S\bar{x}$) (n=10) | | 2nd group (Routine treatment + Oxygen) ($\bar{x} \pm S\bar{x}$) (n=10) | |
|---|---|---|---|---|
| | 0th hour | 24th hour | 0th hour | 24th hour |
| LDH /U/L) | 1301.88±378.35 | 1007.86±124.60 | 1350.67±318.96$^{c}$ | 991.33±205.80$^{d}$ |
| TP (g/dl) | 7.17±0.68$^{a}$ | 6.17±0.49$^{b}$ | 7.27±0.38$^{c}$ | 6.37±0.33$^{d}$ |
| ALB (g/dl) | 3.00±0.18$^{a}$ | 2.78±0.18$^{b}$ | 3.25±0.20 | 3.01±0.09 |
| BUN (mg/dl) | 85.17±17.43 | 75.50±15.71 | 95.75±13.39 | 76.63±8.95 |

LDH: Lactate dehydrogenase; TP: Total protein; ALB: Albumin; BUN: Blood urea nitrogen
- a, b: : in-group comparison of 1st group according to different time periods (0th and 24th)
- c, d: : in-group comparison of 2nd group according to different time periods (0th and 24th)
- For comparing the values of group 1 and 2 in the same time period;
- A: 0th hour, B: 24th hour
Different capital letters indicate significant differences between different groups in the same time period ($p<0.05$). Different lowercase letters indicate significant differences between the different time periods of the same group ($p < 0.05$).

to be statistically significant. There was no statistical significance between the groups in the same time period.

## DISCUSSION

Diarrhea is one of the most common problems of calves and it particularly leads to mortality and serious economic losses during the neonatal period (Ocal et al., 2006; Ozkan and Akgul, 2004; Sen et al., 2013). Dehydration, electrolyte imbalance, metabolic acidosis and hyperkalemia are major complications in calves with diarrhea (Kalinbacak, 2003). Thus, fluid and electrolyte therapy is reported to be crucial along with routine treatment. On the other hand, it is also stated that oxygen therapy could also be useful for supportive treatment (Cambier et al., 2001).

In calf diarrhea, excessive amounts of $H^+$ ions accumulate in plasma and cross into the intracellular fluid, and eventually lead $K^+$ ions to cross into the extracellular fluid, resulting in hyperkalemia. Potassium is the major cation in the intracellular fluid where 98% of its total amount is present. While intracellular concentration of K is 150-160 mmol/L, in the extra-

cellular fluid it is 3.5-5.5 mmol/L. When the concentration of serum potassium exceeds 5.5 mmol/L, this is known as hyperkalemia (Demirel et al., 2006; Ozkan et al., 2016). In this study, diarrheic calves with serum K concentrations greater than 6 mmol/L were included. Hyperkalemia was detected in both groups and normal potassium concentrations were detected following the treatment.

In calves with hyperkalemia, it is crucial to correct hypovolemia, fluid-electrolyte loss, metabolic acidosis and hyperkalemia. For this purpose, using isotonic saline is reported to be useful. Besides, the use of sodium bicarbonate in combination with isotonic saline solution is also extensively used (Sahal et al., 1994; Senturk, 2001; Ocal et al., 2006; Ozkan, 2011; Kizil and Baspinar, 2016). Nevertheless, in several studies similar to ours (Groutides and Michell, 1990; Senturk, 2001; Suzuki et al., 2002; Ocal et al., 2006; Sen et al., 2013), the importance of fluid-electrolyte therapy in calf diarrhea was emphasized. In this study, fluid-electrolyte therapy in both groups with hyperkalemia was also determined to be effective and consistent with the findings of the previous researches.

The evaluation of blood gases and related parameters is important for the diagnosis, treatment and prognosis of acid-base and fluid-electrolyte imbalances, and respiratory system disorders in animals. In order to determine proper electrolyte therapy, the evaluation of parameters such as pH, BE, total $CO_2$, $HCO_3$, Na, K, Cl, Ca and Mg in the blood is very important in deciding the appropriate therapy (Nagy, 2006; Zeybek and Civelek, 2014; Aygencel, 2014). Blood gas analysis is important in acid-base balance and respiratory system disorders.Thus, it is required to measure blood $pO_2$ (partial oxygen pressure), $pCO_2$ (partial carbon dioxide pressure), pH values and $sO_2$ (oxygen saturation), $HCO_3^-$ and BE (base excess) (Sarnaik and Heidemann, 2007; Polat, 2016). In the analysis of blood gases for the definitive diagnosis of metabolic acidosis in calves with diarrhea,it is important to evaluate parameters such as pH, $pCO_2$, $pO_2$ and BE(Kurtdede, 2004). Blood gas analysis is also indicated for the diagnosis and treatment of metabolic and respiratory acidosis and alkalosis, for determining the type of respiratory failure, for monitoring the outcome of the treatment,for following up on the effect of oxygen therapy, and for identifying the sudden onset of unexplained dyspnea(Nagy et al., 2006).

In a study performed in neonatal calves, Baser and Civelek (2013) reported a decline in $HCO_3^-$ value below 20 mmol/L with blood pH of 7.28, which they associated with metabolic acidosis.In another study performed on newborn calves with diarrhea; Sahal et al. (1994) reported low levels of venous blood pH, $HCO_3^-$ and BE values. They measured the pre-treatment blood pH value as 6.833 and BE as 1.2 mmol/L. Also, they found elevation in blood pH, $pCO_2$, $HCO_3$ and BE values following $NaHCO_3$ treatment. On the other hand, Zeybek and Civelek (2014) reported that increased lactate level is also a major cause of metabolic acidosis in calves with acute diarrhea.Since serum lactate level was higher in the animals prior to treatment compared to post treatment findings. The findings reported by the researchers above correspond to the findings of this study carried out on diarrheic calves with hyperkalemia.

Certain supportive treatments should be applied in addition to fluid-electrolyte treatment and routine treatment in calves with diarrhea. Oxygen therapy was also recommended for supportive treatment (Cambier et al., 2001).The primary objective of oxygen therapy is to correct tissue hypoxia. As with all treatment methods, it has been reported that it is extremely important to use oxygen therapy for the appropriate patient, to consider its economic cost and risk of oxygen toxicity (Bellini, 2002; Topeli et al. 2012). Oxygen therapy is required in cases of arterial hypoxemia ($sO_2$<90%, $pO_2$<60 mmHg), tissue hypoxia, hypotension, metabolic acidosis and respiratory distress(Kallstrom, 2002; Topeli et al., 2012). The limit value of $pO_2$ for supplemental oxygen therapy is acceptable at 60 mmHg. The purpose of oxygen therapy is to maintain $pO_2$ above 60 mmHg and $sO_2$ above 90%(Ersoy and Topeli, 2016). The decision to begin oxygen therapy is made by considering both blood gas analysis and clinical signs. To this end, the animal is checked for signs of systemic hypoxia such as tachycardia, dyspnea, cyanosis of the mucous membranes(Kallstrom, 2002; Topeli et al., 2012).

Based on the blood gas analysis, it is recommended to switch to oxygen therapy when $PvO_2$ falls below 40 mmHg and $pO_2$ falls below 60 mmHg (Fitzpatrick and Crowe, 1986). In studies regarding the changes in blood gases after oxygen administration (Wilson et al., 2006; Bleul et al., 2007),elevations of $pO_2$, $PvO_2$, blood pH value and $sO_2$ was reported. Furthermore, Hawkins et al. (1989) reported that oxygen application in cattle with a mask increased blood $O_2$ concentration up to 50%. Loukopoulos and Reynolds (1997) suggested that giving oxygenvia a mask at a flow rate

of 0.5 liters per minute to small animals is more beneficial than other routes of administration.Besides, when administering oxygen by mask, Ersoy and Topeli (2016) suggested the flow rate as 4-6 L/min to avoid carbondioxide accumulation inside the mask. In this study, in addition to routine and supportive treatment, oxygen was given by mask to calves suffering from metabolic acidosis and hyperkalemia. Following oxygen application, increase in blood pH, $pO_2$, $sO_2$; and decrease in $pCO_2$ were detected in all groups at the 5th hour of the study. Furthermore, in the 2nd group of animals those received oxygen; alterations in blood pH and $pO_2$ were statistically significant ($p<0.05$).

There are a variety of clinical findings in calves with diarrhea. These may appear in different degrees and can be severe (Groutides and Michell, 1990; Sahal et al., 1994; Altug et al., 2013). In this study, the heart rate, respiratory frequency, body temperatures and mean age values of the 1st and 2nd group animals according to the clinical findings are given in Table 1. The mean age of the animals in both study groups was similar.After the treatment, it was determined that the heart rate and respiratory rate decreased in both groups of animals, while the decreased body temperature increased after the treatment and returned to normal levels. After oxygen administration, there was recovery in the 2nd group, yet this was not statistically significant ($p>0.05$). Nevertheless, there was a more significant decrease in heart rate in the animals in the 2nd group at the 24th hour, which was also statistically significant ($p<0.05$). The clinical findings observed in this study were consistent with the findings obtained in other studies (Groutides and Michell, 1990; Sahal et al., 1994; Altug et al., 2013), which were recovered after the treatment.

In calves with diarrhea, hematological parameters were reported to be susceptible to change (Kalınbacak, 2003). In a study performed by Ocal et al. (2016) on calves with diarrhea, hematological changes, particularly on RBC, WBC and Hct values were reported. On the other hand, Kumar et al. (2010) performed a study on neonatal calves with diarrhea and reported that Hct and Hb values were elevated prior to treatment and declined to normal levels after the treatment. This was attributed to an increase in hemoconcentration, which was recovered by fluid-electrolyte therapy. Sahal et al. (1994) reported similar results in their study, in which they examined hematological findings in neonatal calves with diarrhea. In our study, RBC, Hct and Hb levels were elevated prior to treatment in animals in the 1st and 2nd groups due to dehydration, and decreased after fluid-electrolyte treatment. The hematological changes obtained in our study are in parallel to previous studies (Şahal et al., 1994; Kumar et al., 2010; Ocal et al., 2016) which were performed on calves with diarrhea.

Changes in biochemical parameters in calves with diarrhea have been reported in previous studies (Groutides and Michell, 1990).Elevation of TP, ALB, urea and creatinine levels which occurred because of dehydration in diarrhea decrease to normal levels after treatment (Kalinbacak, 2003; Ozkan and Akgul, 2003). In this study;TP, ALB, BUN and LDH levels were high before the treatment and decreased after the treatment in both groups which occured due to dehydration. The findings obtained are consistent with previous studies with calves with diarrhea (Groutides and Michell, 1990; Kalınbacak, 2003; Ozkan and Akgul, 2003).

Metabolic acidosis, hyponatremia and prerenal uremia due to dehydration and various changes in blood gas parameters can be observed in calves with diarrhea (Groutides and Michell, 1990; Kalinbacak, 2003).Kizil and Baspinar (2016) reported high potassium levels in calves with neonatal diarrhea, andSahal et al. (1994) and Ocal et al. (2016) reported low levels of pH, $pCO_2$, $pO_2$ and $HCO_3$ in calves with diarrhea which returned to normal levels after the treatment. Ozkan and Akgul (2003) reportedlow levels of Na, Cl and $HCO_3$and high K concentrations in calves with diarrhea. Groutides and Michell (1990) stated that changes in Na, K, Cl, $pCO_2$ and pH levels are important in calves with diarrhea.In this study, as in other studies, pH, $pO_2$, $sO_2$, Na, Cl, $cHCO_3$ values were high, and low levels of $pCO_2$, K, Lac, cBaseEcf, and AnionGap were detected. Also, the alterations in K, pH and $pO_2$ levels were statistically significant ($p<0.05$).

In this study, higherlactate levels were associated with lactate production due to the activation of anaerobic metabolism in calves with diarrhea. Additionally, Sezer et al. (2013) reported that, in addition to metabolic acidosis, in cases where there is not sufficient oxygen in the tissues, metabolic acidosis maybe exacerbated by lactate production in anaerobic metabolism.In this study, the blood gas levels detected were consistent with previous studies in calves with diarrhea(Groutides and Michell, 1990; Sahal et al., 1994; Kalinbacak, 2003; Ozkan and Akgul, 2003; Sezer et al., 2013; Kizil and Baspinar, 2016; Ocal et al., 2016).

## CONCLUSIONS

As a result, oxygen administration in addition to routine diarrhea treatment is thought to have positive effects on pH, $pO_2$, $pCO_2$, $sO_2$ and K. Based on the results obtained in this study, it was concluded that oxygen therapy would be beneficial for calves with diarrhea and hyperkalemia.

## CONFLICT OF INTEREST

The authors declare no conflict of interest.

## ACKNOWLEDGEMENTS

This study was funded by Van Yuzuncu Yil University, Presidency of Scientific Research Project (Project No:TYL-2019-8160)

## REFERENCES

Aygencel G. Interpretation of arterial blood gases.Arch Turk Soc Cardiol. (2014);42(2):194-202.

Altug N, Yuksek N, Ozkan C, KelesI, Basbugan Y, Agaoglu ZT, Kaya A, Akgul Y. Rapid Etiological Diagnosis of Neonatal Calf Diarrhoea with Immunochromatographic Test Kits. Van Vet J. (2013);24(3):123-128.

Baser DF, Civelek T. Correlations between venous acid-base status and renal function in neonatal calves with acute diarrhea. Kocatepe Vet J. (2013);6(1):25-31.

Bellini L. Oxygen theraphy and pulmonary oxygen toxicity. Manuel of pulmonary disease and disorders. Mcgraw-Hill Companies. (2002);1049-58

Bleul U, Lejeune B, Schwantag S, Kähn W. Blood gas and acid-base analysis of arterial blood in 57 newborn calves. Veterinary Record. (2007); 161:688-691.

Cambier C, Clerbaux T, Moreaux B, Detry B, Beerens D, Gustin P. Blood oxygen binding in calves with naturally occurring diarrhea. AJVR. (2001); 62(5):799-804.

Demirel I, Atalan K, Cakar N. Fluid-electrolyte and acid-base balance in intensive care unit. Turkiye Klinikleri J Int Med Sci. (2006);2(18):45-61.

Ersoy EO, Topeli A. Oxygen therapy systems in respiratory failure.J Crit Intensive Care. (2016);7:99-105

Fitzpatrick RK, Crowe DT. Nasal oxygen administration in dogs and cats: Experimental and clinical investigations. J Am Anim Hosp Assoc. (1986);22:293-300.

Groutides CP, Michell AR. Changes in plasma composition in calves surviving or dying from diarrhoea. Br Vet J. (1990); 146:205-210.

Kalınbacak A. Use of the hypertonic saline-dextran and oral electrolyte solution for fluid resuscitation of dehydrated diarrheic calves. Ankara Univ Vet Fak Derg. (2003);50:113-118.

Kallstrom TJ. Oxygen therapy for adults in the acute care facility. Revision and UpDate. Aarc Clinical Practice Guideline. Respir Care. (2002); 47:717-20.

Kizil O, Baspinar B. Potassium levels and heart electrocardiogram in calves with neonatal diarrhea. FU Sag Bil Vet Derg. (2016);30(2):137-139.

Kumar B, Shekhar P, Kumar N. A clinical study on neonatal calf diarrhoea. Intas Polivet. (2010); 11(2): 233-235.

Kurtdede A, Borku MK, Sancak AA, Pekkaya S. Determination of metabolic acidosis and sodium bicarbonate requirement by a micro $CO_2$ system and a blood gase analyser in diarrheic calves. Ankara Univ Vet Fak Derg. (2004);51:105-109.

Loukopoulos P, Reynolds W. Comperative evaluation of oxygen therapy tecniques in anesthetized dogs: Face Mask and Flow- By Tecnique. Aust Vet Practit. (1997);27(1):34-9.

Nagy O, Kovac G, Seidel H, Paulikova I. Selection of arteries for blood sampling and evaluation of blood gases and acid-base balance in cattle. Acta Vet Brno. (2002);71:289-296.

Nagy O, Seidel H, Paulikova I, Mudron P, Kovac G. Use of blood gases and lactic acid analyses in diagnosis and prognosis of respiratory diseases in calves. Bull Vet Inst Pulawy. (2006);50:149-152.

Ocal N, Duru YS, Yagci BB, Gazyagci S. Field condition diagnosis and treatment of acid-base balance disorders in calves with diarrhea. Kafkas Univ Vet Fak Derg. (2006);12:175-183.

Ozkan C, Arslan S, Akgul Y. Sodium, potassium and chloride deficiency in animals. Turkiye Klinikleri J Vet Sci Intern Med-Special Topics. (2016);2(2):32-41.

Ozkan C, Akgul Y. Haematological, biochemical and electrocardiographical findings in neonatal diarrhoeic calves. YYU Vet Fak Derg. (2004);15(1-2):123-129.

Ozkan C, Altug N, Yuksek N, Kaya A, Akgul Y. Assessment of electrocardiographic findings, serum nitric oxide, cardiac troponins and some enzymes in calves with hyperkaliemia related to neonatal diarrhoea. Revue Med Vet. (2011);162(4):171-176.

Polat FR, Coskunkan U, Sakalli O. Acid-base homeostasis and disorders. Int J Basic Clin Med. (2016);4(1):48-52.

Sarnaik AP, Heidemann SM. Respiratory Pathophysiology and Regulation. In: Behrman Re, Kliegman Rm, Jenson Hb (Eds). Nelson Textbook of Pediatrics 18th Edit. Wb Saunders Company, Philadelphia, (2007); 1719-1726.

Sezer K, Duran S, Albay MK, Karakumrum MC. Determination of diagnostic and prognostic importance of the D (-) and L (+) lactic acid and some biochemical and hematological parameters in Holstein dairy cows with abomasal displacement. Kafkas Univ Vet Fak Derg. (2013);19(Suppl-A):A167-A173.

Sahal M, Borku MK, Kalinbacak A, Kurtdede A, Imren HY, Ozlem B, Unsuren H, Tanyel B. Relationship between the criteria based on the Apgar scoring system and venous blood gases, acid-base balance, blood serum glycose, lactate, urea and electrolyte levels in lambs after birth. AU Vet Fak Derg. (1994);41(3-4):373-387.

Sen I, Guzelbektes H, Yildiz R. Neonatal calf diarrhea: pathophysiology, epidemiology, clinic, treatment and prevention Turkiye Klinikleri J Vet Sci.(2013); 4(1):71-78.

Senturk S. Fluid therapy in diarrheic calves. J Fac Vet Med. 2001;20:161-167.

Wilson DV, Schott HC, Robinson NE, Berney CE and Eberhart SW. Response to nasopharyngeal oxygen administration in horses with lung disease. Equine Vet J (2006); 38(3):219-23.

Zeybek S, Civelek T. The time dependent effects of intravenous administration of isotonic sodium bicarbonate on venous acid-base status and renal function in neonatal calves with acute diarrhea. Kocatepe Veterinary Journal. (2014);7(1):39-46.