Original Article https://doi.org/10.47748/tjvr.1788998

TJVR 2026; 10: 19-30

Turkish Journal of Veterinary Research

https://dergipark.org.tr/tr/pub/tjvr

e-ISSN: 2602-3695

Effect of early diagnosis and treatment on some serum biochemical parameters in postpartum left abomasum displacement in dairy cattle

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Received: 22.09.2025 Accepted: 26.10.2025

ABSTRACT

Objectives: In the postpartum period, left abomasum displacement is more common in dairy cattle. Since it causes significant economic losses, the disease should be diagnosed and treated early. This study aimed to investigate the changes in some biochemical parameters in Holstein breed cows with left abomasum displacement diagnosed and treated very early. Cows showing a tendency to decrease in milk yield were examined for displacement using the herd management system.

Materials and Methods: The Liptak test was also applied to the cows with positive ausculto-percussion examination results, and 14 cows were diagnosed with left abomasum displacement. Blood samples were taken from these 14 cows with left abomasum displacement (displacement group) before the operation (hour 0), and at hours 12, 24, 48, 96, and 144 after the operation to investigate AST, GGT, LDH, CK, Na, K, Cl, Ca, P, glucose, amylase, lipase, NEFA, and BHBA levels. In addition, blood was taken once from 14 healthy cows (control group) on the same farm to investigate the above parameters and compared with the displacement group data. In the displacement and control group, animals included in the study, clinical findings such as pulse, respiratory rate, body temperature, and rumen contraction numbers were recorded.

Results: As a result, it was revealed that there were no significant changes in many parameters due to early diagnosis and early initiation of treatment by utilizing the herd management system in the case of left abomasum displacement.

Conclusions: This study revealed that animals treated with left abomasum displacement treatment with the Grymer-Sterner method can regain their health without significant changes in the biochemical parameters observed in the abomasal displacements, without causing significant economic losses in the animals, and keeping the treatment costs at a minimum level.

Keywords: *Left abomasum displacement, Cattle, Biochemical parameters, Grymer- Sterner method*

INTRODUCTION

Abomasum displacements (AD) are multifactorial disorders of dairy cattle, usually seen in early lactation (Gülersoy, 2020; Basoglu et al., 2020; Antanaitis et al., 2020; Maden et al., 2021). Left abomasum displacement (LDA) causes deterioration in the health of dairy cows, decreased fertility, lower milk production, and higher slaughter rates (Fiore et al., 2019; Antanaitis et al., 2020; Guo et al., 2020; Tschoner et al., 2020; Toledo et al., 2021). The abomasum is mostly displaced to the left, but it is also displaced to the right to a lesser extent. Rarely, volvulus may occur in those displaced to the right (Aslan et al., 1997; Wilson, 2008; Zerbin et al., 2015). Left abomasum

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displacement is the movement of the abomasum, which is normally located on the right ventral side of the abdominal cavity, towards the upper left part of the abdomen, filling with gas and settling between the abdominal wall and the rumen. It is especially common in high-yielding dairy breeds (Altan et al., 2012; Guo et al., 2020; Gerspach et al., 2020). The disease occurs due to predisposing factors such as nutrition, breed, genetic predisposition, twin or dystocia, lactation, ketosis, fatty liver, hyperglycemia, hypocalcemia, retained placenta, endometritis, mastitis, and foot diseases (Guo et al., 2020; LeBlanc, 2020; Valergakis et al., 2024). Most left displacement of the abomasum is related to parturition. Cases are usually seen in the first 4 weeks after calving (Guo et al., 2020; Tschoner et al., 2020).

Clinical symptoms such as dehydration due to decreased food and fluid intake, anorexia, decreased milk yield, asymmetry in the left abdominal wall, dark and sticky stools are observed in abomasum displacements. However, it has been reported that there are also cases without symptoms (Parlak and Arıcan, 2016; Guo et al., 2020). In the diagnosis of left displacement, the characteristic ping sound obtained during ausculto-percussion examination of the left abdominal wall is an important clinical finding. In addition, experimental laparoscopy, ultrasonographic examination, and the Liptak test are also among the diagnostic methods (Aksoy et al., 2009; Gouda et al., 2020).

The current study assessed the clinical and biochemical analysis outcomes of 14 animals that were diagnosed and treated promptly when yield loss was noticed, as well as the abomasum displacement in cows whose milk yields were tracked at 8-hour intervals using the herd management system. The Grymer-Sterner method, which is a practical treatment option in the treatment of animals diagnosed with left abomasum displacement, was applied in a short time. Some serum biochemical parameters were investigated before and after treatment. For this purpose, aspartate aminotransferase (AST), gammaglutamyltransferase (GGT), lactate dehydrogenase (LDH), creatine phosphokinase (CK) sodium (Na^+), potassium (K^+), chloride (Cl^-), calcium (Ca), phosphorus (P), glucose, amylase, lipase, non-esterified fatty acid (NEFA) and serum beta hydroxybutyric acid (BHBA) levels were investigated. The purpose of the present study is to investigate the impact of early diagnosis and subsequent treatment on biochemical parameters.

MATERIALS and METHODS

Animal material

The displacement group in this study comprised 14 Holstein cows from the Yalın Livestock Farm in Kayabeyli Village, Lüleburgaz, Kırklareli, Turkey. The cows were diagnosed with left abomasum displacement during their first, second, third and fifth lactation periods. The control group comprised 14 healthy cows from the same farm, housed during the second, third, fourth, and fifth lactation periods (Table 1).

Table 1. Animal material used and lactation periods.

Groups	1. lactation	2. lactation	3. lactation	4. lactation	5. lactation
Group I (LDA)	3	4	2	2	3
Group II (Control)	-	8	3	2	1

*LDA (Left displacement of abomasum)

Clinical examination

Using the herd management program (ALPRO/DeLaval/Sweden), all of the farm's animals were observed every eight hours during the day. By using auscultation and ausculto-percussion testing, it was possible to diagnose left abomasum displacement in the animals that had a lower milk output. The Liptak test was then used to confirm displacement. In animals whose Liptak test content had an average pH of about 3, displacements were determined. Operation was performed on the animals diagnosed with displacement without delay using the Grymer-Sterner method. In the clinical examination performed before the operation (0th hour) and at 12, 24, 48, 96 and 144th hours after the operation, pulsation (number/min) and respiratory rates (number/min), body temperature (°C), rumen contraction number (number/5 min) (Table 2) and dehydration signs were examined. None of the animals with displaced abomasum required fluid therapy.

Collection and storage of blood samples

Six times blood samples were taken from all animals with abomasum displacement included in the study, as before the operation (0th hour) and 12, 24, 48, 96, and 144 hours after the operation, into gel

tubes. Blood samples from the jugular vein were also taken from the animals only once into gel tubes in the control group, which consisted of healthy animals from the same farm. The blood taken into the gel tubes was centrifuged at 3,000 rpm for 15 minutes, and the serum samples obtained were taken into Eppendorf tubes and stored at -20°C until the analyses were performed. Then, the serum samples were sent to the laboratory of the Department of Internal Medicine, Faculty of Veterinary Medicine, Erciyes University, paying attention to the cold chain for the analyses to be performed.

Table 2. Some clinical findings of animals with left abomasum displaced and control groups before (0th hour) and after (12th, 24th, 48th, 96th, 144^{th}hours) treatment and the control group (x ± SD).

Parameters	Group	0th hour	12th hour	24th hour	48th hour	96th hour	144th hour
Pulsation (Beats/min)	Group I (LDA)	68.42±6.51**a	69.78±5.88**b	71.14±6.08**c	75.50±5.57**d	77.71±4.82*e	79.57±4.07*f
	Group II (Control)	82.35±3.00a					
Respiration (respiratory rate/min)	Group I (LDA)	18.07±1.54**a	16.71±1.48**b	15.57±1.45**c	18.21±0.80**ad	21.92±1.49*e	22.85±1.35f
	Group II (Control)	24.14±2.14a					
Body Temperature (°C)	Group I (LDA)	37.76±0.12*a	38.10±0.10*b	38.20±0.08*c	38.41±0.14d	38.47±0.10e	38.50±0.09ef
	Group II (Control)	contraction					
Rumen contraction number (5 min)	Group I (LDA)	10.71±0.99ade	9.21±1.25*bc	8.57±0.93**b	9.92±0.73*cf	10.42±0.75df	10.85±0.77e
	Group II (Control)	10.85±1.46a					

: In comparisons of measurements between groups, there is a statistical difference between the same columns (:p<0.05, **:p< 0.001). In comparisons of measurements within groups, there is a statistical difference (p< 0.05) between rows containing different lowercase letters.

Biochemical analyses

GGT, AST, LDH, CK, amylase, lipase, glucose, Ca, P, Na, K, Cl levels were measured in blood serum samples taken from different groups and times with a Biochemistry device (Cobas c701) at Erciyes University, Gulser-Dr. Mustafa Gundogdu Central Laboratory. Serum BHBA (Randox, Lot. 440696, 01/28/2020) and NEFA (Randox, Lot. 424896, 08/28/2019) measurements were performed using an autoanalyzer (Gesan Chem 200 Autoanylazer SN/1102422, Rome) device at Burdur Mehmet Akif Ersoy University, Faculty of Veterinary Medicine, Animal Hospital Laboratory.

Application of the Grymer-Sterner method

In this study, cows diagnosed with left displacement were operated on using the Grymer-Sterner (1982) method, as specified in the literature.

Statistical analysis

The findings obtained were determined by performing a two-way analysis of variance (two-way ANOVA) in repeated measurements within and between groups using the IBM SPSS 22.0 Windows package program. The conformity of the data to normal distribution was evaluated with Q-Q, histogram, and the Shapiro-Wilk test. Benferoni test was used as a multiple comparison test. A p value of < 0.05 was considered statistically significant.

Ethical approval

The animal use protocol for this study was approved by the Local Ethics Committee on Animal Research of Erciyes University (approval number: 15.11.2017/102).

RESULTS

Pulsation (beats/min), respiratory rates (number/min), rectal temperature (˚C), rumen contraction rates (number/5 min) in the clinical examination performed before the operation (0th hour) and at 12, 24, 48, 96 and 144th hours after the operation are given in Table 2. All operated animals recovered without recurrence.

A statistically significant difference was found between the measurements at 0th, 12th, 24th, 48th, 96th, and 144th hours in the comparison of pulsation levels between groups (p<0.001). When intragroup measurements of the same values were compared, a statistically significant difference was found between the measurements at hours 0, 12, 24, 48, 96, and 144 in the displacement group (p<0.05) (Table 2).

In the comparison of respiration values between groups, a statistical difference was observed between the measurements at 0th, 12th, 24th, 48th, and 96th hours (p<0.001).

In the comparison of intra-group measurements, a

statistical difference was determined between the measurements except for 0th and 48th hours in the displacement group (p<0.05) (Table 2).

The comparison of body temperature values among groups revealed a statistically significant difference (p<0.05) between the measurements taken at 0th, 12th, and 24th hours. There was no discernible statistical difference (p>0.05) between the measures taken at 48, 96, and 144 hours. A statistical difference (p<0.05) was found between all measurements in the comparison among the groups, with the exception of the measurements taken in the displacement group between the 96th and 144th hours. (Table 2).

In the comparison between the groups in the rumen contraction value, a statistical difference was detected between the measurements at 12th and 48th hours (p<0.05) and between the measurements at 24th hours (p<0.001). In the comparison between measurements within the groups, a statistical difference (p<0.05) was detected between the measurements at 0th hours and 12th and 48th hours in the displacement group. No statistical difference (p>0.05) was observed between the measurements at 0th hours, 96th, and 144th hours (Table 2).

Table 3. BHBA and NEFA values (x ± SD) in the left abomasum displaced and control group animals before and 144 hours after treatment.

Parameters	Group	0th hour	144th hour
BHBA(mmol/L) *x* ± SS	Group I (LDA)	0.42±0.29[a]	0.43±0.10*[a]
	Group II (Control)	0.60±0.10[a]	0.60±0.10[a]
NEFA(mmol/L) *x* ± SS	Group I (LDA)	0.03±0.01**[a]	0.23±0.18b
	Group II (Control)	0.15±0.04[a]	0.15±0.04[a]

: In comparisons of measurements between groups, there is a statistical difference between the same rows (:p< 0.05, **:p< 0.001). In the comparison of measurements within groups, there is a statistical difference (p<0.05) between the columns containing different lowercase letters.

Table 4. Some biochemical parameters (x ± SD) in left abomasum displaced and control group animals before and after treatment.

Parameters	Group	0th hour	12th hour	24th hour	48th hour	96th hour	144th hour
GGT (U/L) *x*±SS	Group I (LDA)	54.21±33.38abcd	56.28±33.15*a[bc]	49.42±20.54a[bcd]	53.78±32.61c	46.21±24.51[d]	49.85±26.41a[bcd]
	Group II (Control)	35.42±16.86a	35.42±16.86 a	35.42±16.86a	35.42±16.86a	35.42±16.86a	35.42±16.86a
AST (U/L) x±SS	Group I (LDA)	125.28±42.85a	125.71±42.88a	119.42±40.37a	113.71±39.64a	108.92±74.33a	116.28±73.56a
	Group II (Control)	112.42±32.66a	112.42±32.66a	112.42±32.66a	112.42±32.66a	112.42±32.66a	112.42±32.66a
LDH (U/L) x±SS	Group I (LDA)	1391.14±497.9 abcd	1413.92±529.78a[bc] d	1321.14±465.44a[bc] d	1423.35±623.30[bd]	1269.64±648.91c	1380.50±632.23[d]
	Group II (Control)	1268.00±389.56a	1268.00±389.56 a	1268.00±389.56a	1268.00±389.56a	1268.00±389.56a	1268.00±389.56a
CK (U/L) x ± SS	Group I (LDA)	306.92±131.49*a	341.71±244.56*a	350.78±186.08*a	295.64±116.29* a	466.64 ±886.9 7a	433.50±814.04a
	Group II (Control)	183.71±50.75a	183.71±50.75a	183.71±50.75a	183.71±50.75a	183.71±50.75a	183.71±50.75a
AMYLASE (U/L) *x* ± SS	Group I (LDA)	47.57 ±26.5 g*abc	41.50±13.48*a[bc]	41.78±10 .67*[b]	39.92±13.53*a[bc]	33.14±11.61c	40.85±16.03*a[bc]
	Group II (Control)	28.71±10.54[a]	28.71±10.54[a]	28.71±10.54[a]	28.71±10.54[a]	28.71±10.54[a]	28.71±10.54[a]
LIPASE (U/L) x±SS	Group I (LDA)	6.28±3.49[a]	6.35±3.05[a]	6.00±3.01[a]	5.85±2.41[a]	5.64±2.16[a]	5.42±2.02[a]
	Group II (Control)	6.07±1.49[a]	6.07±1.49[a]	6.07±1.49[a]	6.07±1.49[a]	6.07±1.49[a]	6.07±1.49[a]
GLUCOSE (mg/dL) x ± SS	Group I (LDA)	53.42±23.52a	55.85±18.93[a]	58.14±15.56[a]	60.14±24.75[a]	58.92±24.18[a]	59.78±28.43
	Group II (Control)	50.00±5.09[a]	50.00±5.09[a]	50.00±5.09[a]	50.00±5.09[a]	50.00±5.09[a]	50.00±5.09[a]

:Indicates that there is a statistical difference between the same rows in comparisons of measurements between groups (:p<0.05, **:p<0.001). In comparisons of measurements within groups, there is a statistical difference (p<0.05) between columns with different lowercase letters.

Table 5. Some trace element levels (x±SD) in the left abomasum displaced and control group animals before and after treatment.

Parameters	Group	0th hour	12th hour	24th hour	48th hour	96th hour	144th hour
Ca (mg/dL) $x \pm SS$	Group I (LDA)	8.59±1.14^{ad}	8.83±1.13^{ab}	9.03±1.14^{be}	9.25±0.81^{be}	9.21±0.57^{ab}	8.83±0.5^{cde}
	Group II (Control)	8.91±0.44^{a}	8.91±0.44^{a}	8.91±0.44^{a}	8.91±0.44^{a}	8.91±0.44^{a}	8.91±0.44^{a}
P (mg/dL) $x \pm SS$	Group I (LDA)	5.71±1.01*^{a}	5.92±1.17*^{a}	5.89±1.08*^{a}	5.60±1.15*^{a}	5.35±0.91**a	5.33±0.96 **^{a}
	Group II (Control)	6.84±0.89^{a}	6.84±0.89^{a}	6.84±0.89^{a}	6.84±0.89^{a}	6.84±0.89^{a}	6.84±0.89^{a}
Na (mmol/L) $x \pm SS$	Group I (LDA)	141.57±3.91^{a}	139.57±3.77^{ab}	139.00±4.99^{ab}	138.57±2.92^{bc}	140.07±2.16^{ab}	140.00±2.41^{ab}
	Group II (Control)	139.21±5.39^{a}	139.21±5.39^{a}	139.21±5.39^{a}	139.21±5.39^{a}	139.21±5.39^{a}	139.21±5.39^{a}
K (mmol/L) $x \pm SS$	Group I (LDA)	4.40±0.77^{ab}	4.70±0.71**^{b}	4.67±0.67 **^{b}	4.40±0.55*^{ac}	4.24±0.62 ^{ac}	4.32±0.56*^{ac}
	Group II (Control)	3.97±0.23^{a}	3.97±0.23^{a}	3.97±0.23^{a}	3.97±0.23^{a}	3.97±0.23^{a}	3.97±0.23^{a}
Cl (mmol/L) $x \pm SS$	Group I (LDA)	93.21±7.71^{ab}	94.57±6.53^{b}	94.28±8.32^{b}	90.78±9.82^{ac}	90.42±13.23^{abc}	91.50±11.97^{abc}
	Group II (Control)	92.21±4.29^{a}	92.21±4.29^{a}	92.21±4.29^{a}	92.21±4.29^{a}	92.21±4.29^{a}	92.21±4.29^{a}

:Indicates that there is a statistical difference between the same rows in the comparisons of measurements between groups (:p<0.05, **:p<0.001). In the comparisons of measurements within groups, there is a statistical difference (p<0.05) between the 5 columns containing different lowercase letters.

The left abomasum displacement and Control Group animals had their BHBA and NEFA values assessed before treatment (0th hour) and 144 hours after treatment. The findings are presented in Table 3. Table 4 shows the results of the analysis of selected biochemical parameters in the blood serum of the displacement and control groups before surgery (0 hours) and at 12, 24, 48, 96 and 144 hours after the procedure. Table 5 presents the levels of several trace elements.

In the comparison between the groups in BHBA concentrations, a statistical difference was observed between the measurements at 144th hour, and the BHBA concentrations were found to have decreased (p<0.05). In the comparison within the group, no statistical difference was detected (p>0.05).

A statistical difference was seen between the measurements at the 0th hour and a decrease in the NEFA concentrations (p<0.001) in the comparison of the NEFA concentrations between the groups. A statistically significant difference (p<0.05) was found when comparing the data among the groups. An increase was found in the displacement group between the 0th and 144th hour measures.

There was a statistically significant difference (p<0.05) in the comparison of the groups' serum GGT activity, with an increase seen at the 12th hour. A statistically significant decrease was seen between the measurements taken at the 12th and 96th hour, as well as between the 48th and 96th hour, in the displacement group (p<0.05), when the measurements within the groups were compared with each other.

No statistical difference was observed in the comparison of serum LDH values between the groups (p>0.05). A statistical difference was observed in the displacement group between the measurements at the 48th and 96th hours, indicating a decrease, and between the measurements at the 96th and 144th hours, indicating an increase (p<0.05).

In the comparison of serum CK activity between the groups, a statistical difference was determined between the 0th, 12th, 24th, and 48th hours (p<0.05).

In the comparison of serum amylase activity between the groups, a difference was determined between the 0th, 12th, 24th, 48th, and 144th hours (p<0.05). In the comparison of the measurements within the groups, a statistical difference was observed between the measurements at the 24th and 96th hours in the displacement group, and a decrease was detected (p<0.05).

In the comparison of serum lipase and AST activity and glucose level, no statistical difference was detected between the groups and within the groups (p>0.05).

There was no statistical difference in the calcium value between the groups (p>0.05). In the comparison of the measurements within the groups, in the displacement group, there was an increase between the measurements at 0 hours and at 24 and 48 hours, and a decrease between the measurements at 96 and 144 hours (p<0.05).

There was a significant difference in phosphorus (p) values among the groups at the 0, 12, 24, and 48-hour measurements ($p<0.05$). No statistical difference was found between the measurements at 96 and 144 hours ($p<0.001$). No statistical difference was observed between the measurements within the groups ($p>0.05$).

In the comparison of Na values between the groups, no statistical difference ($p>0.05$) was determined. In the comparison of intra-group measurements, a statistical difference was observed between the measurements at 0 and 48 hours in the displacement group, and a decrease was detected ($p<0.05$).

In the comparison of potassium (K) values between the groups, a statistical difference was determined in the direction of increase between the measurements at 12 and 24 hours ($p<0.001$), and a statistical difference was determined in the direction of increase between the measurements at 48 and 144 hours ($p<0.05$). In the comparison of intra-group measurements, a decrease was determined between the measurements at 12 and 24 hours and the measurement at 48 hours in the displacement group, and a statistical difference was observed ($p<0.05$).

When the groups' chloride (Cl) values were compared, there was no statistically significant difference found ($p>0.05$). Comparing the intra-group data, it was found that there was a statistically significant difference ($p<0.05$) between the measures taken at the 12th and 24th hours and between the 48th hour in the displacement group.

DISCUSSION

The most frequent clinical signs in abomasum displacements include a sudden decrease in milk production and appetite (Wilson, 2008; Gouda et al., 2020). Since the dairy farm in the present study used the herd management system (ALPRO/DeLaval/Sweden), the animals' feed consumption and milk yield were tracked at 8-hour intervals. In particular, animals exhibiting abrupt drops in milk yield had regular checks for abomasum displacement. In fact, there are other studies using herd management systems in early diagnosis of AD (Antanaitis et al., 2009). Caixeta et al. (2018) reported that farmers and veterinarians should routinely monitor the health and nutrition of dairy cows during the transition period to prevent the occurrence of abomasum displacements. The same researchers also recommended the use of a reliable and effective data recording system to monitor disease cases on farms, including abomasum displacements. Therefore, this study demonstrates the importance of using reliable and effective data recording systems for herd health. In this context, the herd management system in the current study played a crucial role in diagnosing the disorder before various potential biochemical changes occur. This monitoring system is reported to be important not only for the early diagnosis of abomasum displacements but also for the diagnosis of many metabolic disorders in dairy cattle (Caixeta et al., 2018). As in this study, early diagnosis of abomasum displacement prevented potential changes in organs and systems by initiating treatment. The early onset of recovery from treatment also minimized significant economic losses. One of the weaknesses of this study is the small number of animals with abomasum displacement. Therefore, we believe that future studies involving a larger number of animals with displacement will further clarify this issue. It is well recognized that the diagnosis of abomasum displacements involves the use of clinical examination, ultrasonographic examination, Liptak test, laboratory results, and experimental or laparoscopic procedures (Wilson, 2008). In this investigation, the lower region of the area where the pink sound was heard, which was one hand broad, was used for the Liptak test. Clinical ausculto-percussion examination was conducted for displacement in the animals exhibiting a sudden decrease in milk supply. Based on the Liptak test results, animals with a pH of around 3 had the displacement diagnosis confirmed. In this study, the farm where the disease was diagnosed lacked an ultrasound device, so diagnosis was made solely using ausculto-percussion/Liptak tests. However, we believe that, if possible, adding ultrasonography to the tests used in this study in future studies would further strengthen the diagnosis.

The animal material used in the study is given in Table 1. Displacement Group animals in the present study are almost similar in number and consist of different lactation periods. A significant portion of the control group animals (8 animals) were from the second lactation period. Since the displacement group used in the present study was not selected based on the cows' lactation stages, the control group was also not specifically selected based on their lactation stages. The lactation distribution of the animals in the control group in our study was

shaped by the animals that gave birth during the study period. The main reason for the higher number of animals in the second lactation in the control group compared to the other lactation groups is that the majority of the animals giving birth during the study period were in the second lactation. The fact that most of these animals gave birth at the same time and were kept under the same feeding conditions contributed to the standardization of both environmental and physiological factors. Furthermore, the evaluations revealed that the number of lactations did not have a significant effect on the parameters studied. Therefore, including a larger number of animals from the second lactation in the control group did not compromise the purpose or methodological integrity of the study. However, a separate study in healthy animals is needed to determine whether there are differences between lactation stages. The number of abomasum-displaced animals might be low in the present study due to project expenses, but future studies in this manner shall be performed on more affected animals.

Clinical findings were also recorded for the pulsation, respiration rate, body temperature, and rumen contractions of the two groups of research animals. The values obtained at various intervals were compared with the data obtained once from the Control Group.

A statistical difference ($p<0.05$) was seen between the pulsation values before and after treatment in the Displacement Group when the pulsation was analyzed among the clinical data studied in this study. Following treatment, the pulsation value grew gradually, and at the 144th hour, it approximated the values of the Control Group. A statistical difference was found between the values of the Control Group ($p<0.001$), with the exception of the 144th hour. Dezfouli et al. (2013) and Ismael et al. (2018) found the heart rate to be higher in the left displacement group than in the Control Group, contrary to the values obtained in the present study. This may be explained by the fact that in the above studies, the disease of animals with left abomasum displacement was probably diagnosed much later than in the present study and almost all parameters were very high. However, in the present study, left displacement was suspected at the very beginning of the disease, before clinical symptoms appeared. Therefore, only milk yield loss was taken into account and left abomasum displacement was diagnosed within 8 hours with additional clinical tests.

In the current investigation, respiration rates increased until the 144th hour, nearing the Control Group values, and were shown to be considerably ($p<0.05$) lower in the Displacement Group than in the pre-treatment values. The results of the group comparison showed that the data from the Control Group were consistently considerably higher ($p<0.001$) than the data from the Displacement Group. However, in contrast to the results of the current investigation, Dezfouli et al. (2013) and Ismael et al. (2018) discovered in their investigations that the respiratory rate was higher in the left displacement group in comparison to the control group. This situation can be associated with the progression of the disease, as explained in the pulsation values.

At hour 0, there was a statistically significant difference ($p<0.05$) in the body temperature values between the control group and the displacement group. With the exception of hour 0 in the displacement group, no significant differences were found between the time periods in the intragroup comparison. While Dezfouli et al. (2013) reported that the body temperature in the displacement group was higher, the present investigation indicated that it was lower in the displacement group than in the control group. On the other hand, Ismael et al.'s study (2018) discovered that body temperature was within normal ranges. The results in the present study can be associated with early diagnosis of the disease and early initiation of treatment.

When rumen contractions in the displacement and control groups were compared, it was observed that rumen contractions decreased in the displacement group 12, 24, and 48 hours after treatment and started to return to normal after the 96th hour. This value was not statistically different from the Control Group values before treatment (0th hour). However, Dezfauli et al. (2013) and Ismael et al. (2018) determined that rumen contractions decreased in displacement patients. In the present study, since the disease was diagnosed early and treated before rumen functions were significantly affected, no difference was determined at the 0th hour compared to the control group. However, because a traumatic procedure was applied to the abomasum after treatment in the present study, a decrease in rumen movements was observed, but rumen movements returned to normal in the following sampling hours due to the recovery of the traumatic effect.

It has been stated in various literature that there are

significant changes in abomasum displacements and the importance of determining various biochemical parameters and some trace element levels used in the diagnosis and prognosis of the disease (Zadnik, 2003; Maden et al., 2012; Aydoğdu and Güzelbektaş, 2013). In the current study, GGT enzyme activity was determined to be higher in the displacement group at 0 hours and higher at 12 hours compared to the control group, and a statistical difference was determined between the values at 0 and 12 hours with the control group ($p<0.05$), but it showed a decreasing trend until the 144th hour. Although the displacement group values were higher than the control group values, no statistical difference was observed except for the 12th hour. Although some differences were determined between the hours in the intra-group comparisons, no significant difference was observed compared to the pre-treatment value (0 hour) (Table 3). GGT originating from hepatobiliary and hepatocellular membranes is affected by cholestasis and related hepatobiliary system diseases in ruminants (Stojević et al., 2005). It has been reported that liver dysfunction may occur as a result of severe liver steatosis in many displacements (Muylle, 1990; Civelek, 2011). In addition, there are many studies reporting that GGT activity is seriously increased in cattle with abomasum displacement (Sevinç et al., 2002; Gülersoy, 2020; Basoglu et al., 2020). The GGT activity, which is 20-29 U/L in healthy cows, was determined as 35.42±16.86 U/L in healthy cattle in the present study. Although a statistical increase ($p<0.05$) was determined in the GGT activity at the 12th hour in the present study (56.28 U/L±33.15), the reason why an excessive increase was not observed is that the disease is diagnosed early and treatment is started early, and the liver steatosis that may occur as a result of displacement is kept at a minimum level.

In the present study, no statistical difference was determined in the AST values between the groups and within the group comparisons. AST is widely found in the liver, muscle tissue, and erythrocytes. The normal AST value in cattle is 78-132 U/L on average (Şentürk, 2017). In the present study, this value in the displacement group was 125.28±42.85 U/L on average before treatment and showed a gradual decrease until the 144th hour, reaching an average of 116.28±73.56 U/L. The AST values obtained from the control group animals were determined to be 112.41±32.66 U/L on average. AST is generally used in the detection of muscle degeneration, together with CK activity. It is also reported to increase in fatty liver (Steen, 2001). Aslan et al. (1997) found that there was an increase in AST levels in abomasum displacements and that this was due to the damage caused by the accumulation of fat in hepatocytes and even in the kidneys, heart, and skeletal muscles during displacement. The reason why no significant increase in AST levels was observed in the present study could be attributed to the early diagnosis and treatment of the disease and keeping the potential fatty liver at a minimum level.

When the CK values obtained from the displacement group were compared with the same value obtained from the control group, it was determined that the values obtained from the displacement group were statistically significantly higher ($p<0.05$) at the 0, 12, 24, and 48th hours. No statistical difference was observed in the comparison of the measurements within the groups. CK is accepted as an indicator of damage in muscle cells (Boyd, 1983; Maden et al., 2012). In a study, it was stated that the CK value increased more in right displacements than in left displacements (Maden et al., 2012). In this study, the CK value increased even more after the operation and reached the maximum level at the 144th hour. The reason for this was thought to be muscle damage due to the operation performed for therapeutic purposes in the present study.

In the lipase value, no statistical difference ($p>0.05$) was detected in the comparison between the groups and within the groups. Since this enzyme is also one of the exocrine secretions of the pancreas, the serum value may be affected in cases affecting the ducts, but in the present study, we believe that the lipase values were not affected because the disease was diagnosed early, and the treatment was also done early.

When the glucose value determined in this study was examined, no statistical difference was observed between the values of the displacement group and the control group, and in comparison within the displacement group. In cattle, a glucose level below 45 mg/dL is considered hypoglycemia, and above 75 mg/dL is considered hyperglycemia (Şentürk, 2017). In this study, the glucose value was determined as 50.00±5.09 mg/dL in the control group animals, while this value was determined as 53.42±23.52 mg/dL in the displacement group before treatment. Although this value increased to 59.78±28.43 144 hours after treatment, no statistical difference was determined. In fact, it is reported in

the literature that there will be no significant changes in blood glucose levels in left abomasum displacements (Sevinç et al., 2002; Civelek, 2011). On the other hand, there are studies reporting that blood glucose levels are unimportant in the diagnosis of displacement (Geishauser et al., 1998), as well as studies reporting that blood glucose levels in cows that died as a result of displacement were twice as high as those that survived (Markiewicz et al., 2009).

In this article, when the Ca value of the displacement and control groups was compared, no statistical difference was observed. However, in the comparisons within the displacement group, although some differences were observed, it was determined that the Ca value was within the literature limits. On the other hand, there are many studies reporting that there will be a decrease in serum Ca concentrations in abomasum displacements (Aslan et al., 1997; LeBlanc, 2020). In a study conducted by Stengärde and Pehrson (2002), it was stated that 95.6% of cows with a blood Ca concentration of 2 mmol/L were diagnosed with abomasum displacement and that there was a significant correlation between Ca and displacement. In the present study, animals diagnosed with left abomasum displacement were diagnosed early as a result of following up with the patient record system and treated before significant changes in Ca values occurred, and it was concluded that this parameter was not significantly affected.

In the current study, when the displacement group P data were compared with the control group data, it was determined that the values obtained at 0, 12, 24, and 48 hours were significantly ($p<0.05$) lower than the control group. P insufficiency is generally more common in cattle than in other animals (Aydoğdu and Güzelbektaş, 2013), because daily phosphorus requirements increase in cases such as pregnancy, growth, and milk yield. The normal P value is 4.5-6.5 mg/dL, and clinical findings of insufficiency are observed when this value falls below (Şentürk, 2017). In the current study, although the displacement group P values were initially lower than the control group values, it was determined that this value was within the reference (5.71±1.01 mg/dL) limits. We can again attribute this to early diagnosis and treatment. On the other hand, there are also studies reporting that the P value does not change significantly in displaced animals (Houe et al., 2001).

In the present study, no statistical difference was determined in the comparison of Na values between the groups. In the comparison of the measurements within the groups, a statistical difference ($p<0.05$) was observed between the measurements at 0 and 48 hours in the displacement group. A decrease in serum Na value below 132 mEq/L is called hyponatremia and is seen in abomasum dilatation, abomasum displacement, torsion, and abomasal volvulus, pathological changes in the intestines, urinary bladder ruptures, and calf diarrhea (Şentürk, 2017). There are studies reporting that there is a slight effect on Na concentration in left abomasum displacements (Şahal et al., 1997). In another study (Gülersoy, 2020), it was stated that Na concentration was lower than in the control group but within the reference limits. In another study, Kurucaoglu (2020) could not determine a statistical difference compared to the Control Group. In the present study, as with other parameters, this parameter was not significantly affected, probably because the disease was diagnosed early and treatment was started immediately.

When the K value was examined, it was determined that there was a statistical difference between the values of the displacement group and the control group in both the measurements at 12 and 24 hours ($p<0.001$) and the measurements at 48 and 144 hours ($p<0.05$). In the comparison of the measurements within the groups, a statistical difference ($p<0.05$) was observed in the measurements between the measurements at 12 and 24 hours and the measurement at 48 hours in the displacement group. 98% of K, which has very important functions in the living organism, is found inside the cell, and only 2% is found outside the cell. A decrease in the serum K concentration below 3.5 mmol/L is called hypokalemia (Şentürk, 2017). Hypokalemia develops in many problems, including abomasum displacements. It is reported that when the K value falls below 2.5 mEq/L, it paves the way for displacement (Weiner and Wingo, 1997). On the other hand, in the current study, the K values were found above 4 mmol/L in the displacement group. The control group value was determined to be 3.97±0.23 mmol/L. Therefore, hypokalemia was not detected in the displacement group in this study. The reason for this may be that the disease was diagnosed and treated before it had a chance to worsen.

When Cl values were examined in this study, no statistical difference was observed in the comparison between the groups. In the comparison

between the measurements within the groups, a statistical difference ($p<0.05$) was determined in the measurements between the 12th and 24th hours and the 48th hour in the displacement group. The most important cation of the extracellular fluid is Cl^-. Especially in cases such as reflux and vomiting caused by abomasum displacements, Cl^- loss occurs. As a result, the pH and bicarbonate values in the blood increase, and hypokalemia and hypochloremia are followed by metabolic alkalosis, which is an important complication of abomasum displacements (Mecitoğlu, 2010; Bayne and Edmondson, 2021). However, in the present study, hypokalemia did not develop in the displacement group, nor did hypochloremia develop. As a result, metabolic alkalosis, which is an important complication of abomasum displacements, was prevented with early diagnosis and treatment.

In this study, only the concentrations of BHBA and NEFA before treatment (0th hour) and 144 hours after treatment were investigated. When the BHBA concentrations between the groups were examined, no statistically significant difference was determined at the 0th hour. However, a statistical difference ($p<0.05$) was observed between the value obtained from the displacement group at 144th hour and the control group. BHBA concentrations increase as a result of negative energy balance, especially in the postpartum period (LeBlanc et al., 2005; Şen et al., 2015). In addition, it was determined that the frequency of left abomasum displacement was 3 or 4 times higher in cows with BHBA>1200 or >1400 ımmol/L in the first 7 days after birth (Şen et al., 2015). In this study, the BHBA concentrations in the displacement group were lower compared to the control group, which contradicts the literature data. This situation is probably related to the early diagnosis and treatment of the disease.

In the comparison of NEFA concentrations between the groups, a statistical difference ($p<0.001$) was observed between the measurements at 0th hours. In the comparison of the measurements within the groups, a statistical difference ($p<0.05$) was also observed between the measurements at 0th and 144th hours in the displacement group. The energy deficit resulting from negative energy balance is met by NEFA. Serum concentration is generally stable between <0.1-2.5 mmol/L. NEFA amount increases as a result of the disruption in lipid metabolism in displacements (Zadnik, 2003; Citil et al., 2003; Ospina et al., 2010). In a study, it was reported by Ospina et al. (2010), which exceeded the reference value in 15% of the cases. In the present study, although NEFA concentrations increased compared to the control group at 144th hours after treatment, this value was also lower than the control group values. This situation may have occurred because the animal lost its appetite for a while after surgical intervention. Moreover, it was determined that this increase was not as much as stated in the literature.

Although various methods are used in the surgical treatment of abomasum displacement, the Grymer-Sterner method is one that can be easily and quickly applied under farm conditions without requiring extensive equipment, tools, or instruments. Of course, it has advantages and disadvantages compared to other techniques. Indeed, in a study conducted by Aksoy et al. (2009), they stated that abomasum displacements can be treated using open [surgical (omentopexy, pyloropexy, abomasopexy, one-step and two-step laparoscopic abomasopexy)] or closed [non-surgical (Toogle Pin Method, Grymer-Sterner Method)] methods, and that closed techniques are economical, rapid, and easily applicable. They also reported that the Grymer-Sterner method is a closed technique using toggle pins to fix the abomasum in its normal location. This method is non-invasive, requires minimal instrumentation, and provides a reliable method for rapid recovery. Some techniques are easy to perform, while others are expensive due to the need for machinery and equipment. In open surgical methods, in particular, the wound healing process is prolonged, which also prolongs patient follow-up. However, it is beneficial to follow up for 30 days following treatment, especially to monitor for recurrences (Parlak and Arıcan, 2016).

In recent years, various biomarkers, metabolomics, and oxidative stress parameters have been the subject of research aimed at early diagnosis of the disease. Further studies on these topics in patients with displacement have the potential to increase the likelihood of early diagnosis.

CONCLUSION

As a result, it has been revealed that abomasum displacements are commonly seen in dairy Holstein cows, and it is important to diagnose the disease early if displacement has developed. It has been documented that milk yields of animals should be followed using herd management systems, especially for the monitoring of herd health. It has been revealed that in sudden decreases in milk yields, it is possible to diagnose abomasum displacement early by using both ausculto-percussion and Liptak tests, and if possible, by

using ultrasound findings. It has also been revealed with this research that the disease can be treated in a short time with the Grymer-Sterner method without causing significant changes in many parameters previously mentioned, that there will be no recurrences, and that animals can regain their health without causing significant economic losses in animals, and by keeping treatment costs at a minimum.

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ACKNOWLEDGMENTS

Author contributions: İK and YM designed the study. The field studies were conducted by YM. İK and YM participated in drafting and revising the manuscript. İK: İhsan Keleş, YM: Yavuz Musabeşeoğlu.

Financial Disclosure: This study was supported by the Erciyes University Scientific Research Projects Unit (BAP) under the project code TYL 2018-8588.

Conflict of Interests: The authors declared that there is no conflict of interests.

Additional information: This study is summarized from a Master's Thesis of first author. All authors have read and agreed to the published version of the manuscript Correspondence and requests for materials should be addressed to YM.

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