Turkish Veterinary Journal, 4(1): 18-23, 2022
DOI:10.51755/turkvetj.1172715

Turkish Veterinary Journal

| tvj.cumhuriyet.edu.tr | Founded: 2019 Available online, ISSN: 2667-8292 Publisher: Sivas Cumhuriyet Üniversitesi

Metabolic Profile in Dairy Cattle with Displacement of the Abomasum

Alparslan Coskun[1,a], Ugur Aydogdu[2,b*], Hasan Guzelbektes[3,c], Ismail Sen[4,d]

[1]1Department of Internal Medicine, Faculty of Veterinary Medicine, Sivas Cumhuriyet University, Sivas, Türkiye
[2]Department of Internal Medicine, Faculty of Veterinary Medicine, Balikesir University, Balikesir, Türkiye
[3]Department of Internal Medicine, Faculty of Veterinary Medicine, Selcuk University, Konya, Türkiye
[4]Department of Internal Medicine, Faculty of Veterinary Medicine, Kyrgyz Turkish Manas University, Bishkek, Kyrgyzstan

**Corresponding author*

Research Article

History

Received: 08/09/2022
Accepted: 30/09/2022

ABSTRACT

The objective of this research was to evaluation metabolic, biochemical and haematological parameters in dairy cattle with displacement of the abomasum (DA). In this study, 80 dairy cattle with DA and 10 healthy dairy cattle in early lactation were used. Jugular venous blood samples for blood gases, haematological parameters and serum biochemical analysis of all cattle were taken. Glucose, lactate, triglycerides, BHB, NEFA, insulin, VLDL, GGT, CK concentrations and pH and haematocrit value of cattle with DA were significantly (P<0.05) higher compared to control cattle. Whereas cholesterol, total protein, Na+, K+ and iCa+2 levels in dairy cattle with DA were significantly (P<0.05) decreased compared to control cattle. In conclusion, displacement of the abomasum is usually associated with haemoconcentration, electrolyte and energy imbalance, and disturbances in hepatic function.

Keywords: Dairy cattle, displacement of the abomasum, metabolic profile

Abomasum Deplasmanlı Süt Sığırlarında Metabolik Profil

Süreç

Geliş: 08/09/2022
Kabul: 30/09/2022

ÖZ

Bu araştırmanın amacı, abomazum deplasmanlı (AD) süt sığırlarında metabolik, biyokimyasal ve hematolojik parametreleri değerlendirmektir. Bu çalışmada AD'lı 80 süt sığırı ve erken laktasyonda 10 sağlıklı süt sığırı kullanıldı. Tüm sığırlardan kan gazları, hematolojik parametreler ve serum biyokimyasal analizleri için juguler venöz kan örnekleri alındı. Abomazum deplasmanlı sığırların glukoz, laktat, trigliseritler, BHB, NEFA, insülin, VLDL, GGT, CK konsantrasyonları ile pH ve hematokrit değerleri kontrol sığırlarına göre önemli ölçüde (P<0.05) yüksek bulundu. Aksine, AD'lı süt sığırlarında kolesterol, total protein, Na+, K+ ve iCa+2 seviyeleri kontrol sığırlarına göre önemli ölçüde (P<0.05) düşüktü. Sonuç olarak, abomazumun deplasmanı genellikle hemokonsantrasyon, elektrolit ve enerji dengesizliği ve hepatik fonksiyon bozuklukları ile ilişkilidir.

Anahtar Kelimeler: Anahtar Kelimeler: Süt sığırı, abomazumun deplasmanı, metabolik profil

[a] acoskun@cumhuriyet.edu.tr 0000-0002-2242-9647
[b] ugur.aydogdu@balikesir.edu.tr 0000-0002-9828-9863
[c] hasan.guzelbektes@manas.edu.kg 0000-0002-0227-0691
[d] ismail.sen@manas.edu.kg 0000-0002-2965-7183

How to Cite: Coskun A, Aydogdu U, Guzelbektes H, Sen I (2022) Metabolic Profile in Dairy Cattle with Displacement of the Abomasum, Turkish Veterinary Journal, 4(1): 18-23

Introduction

The aetiologies of periparturient diseases such as ketosis, fatty liver, abomasum displacements, clinical hypocalcemia, retentio secundinarum and metritis in cattle are closely related to each other. The increase in the incidence of diseases in this period, which is also called the transition period, may cause serious yield losses (low fertility, decrease in milk yield or milk fat ratio, increase in lameness, etc.). The incidence of postpartum metabolic and infectious diseases in dairy cattle is between 35-50% (Leblanc 2010) and displacements of the abomasum have an important place in this rate. Although the incidence of displacement of the abomasum varies according to the countries, it can reach 30% (Bartlett et al., 1995; Van Winden and Kuiper, 2003; Momke et al., 2012). In cattle, 85% of the cases of displacement of the abomasum are in the form of left displacement (LDA), 9% of them are in the form of right displacement (RDA), and 6% are in the form of abomasal torsion (Guard, 1996; Sen et al., 2015).

Decreased abomasum motility and increased content (gas and liquid) in the abomasum are effective in the etiology of the disease (Doll et al., 2009; Sen et al., 2015). Although the etiology of DA is multifactorial (Madison and Troutt, 1988; Constable et al., 1992), volatile fatty acids released in the rumen of animals fed with high-concentrated diet decrease abomasum motility and increase intraabomasal osmotic pressure. Thus, the extracellular fluid passes into the lumen and causes the dilatation of the abomasum, paving the way for displacement. Abomasal atony/hypotonia or gas filling of the abomasum are two important factors that play a role in the formation of DA (Constable et al., 1992). Abomasal hypomotility, endotoxemia (Geishauser 1995), hypocalcaemia (Jorgensen et al., 1998), dry matter intake (Van Winden and Kuiper, 2003), metabolic disorders (Sen et al., 2006), alkalemia (Constable et al., 1992), hypergastrinemia (Sen et al., 2002), insulinemia (Pravettoni et al., 2004), nutrition (Geishauser et al., 2000), increase in the concentration of volatile fatty acids in the abomasum, etc. have been considered to contribute to the development of DA.

In this study, it was aimed to reveal the haematological, biochemical and metabolic changes in dairy cattle with the DA.

Materials and Methods

Eighty dairy cattle diagnosed with DA by result of clinical and laboratory evaluations were included in the study. Diagnosis of displacement of the abomasum in cattle was made by routine physical examination, hearing ping and splashing sounds during simultaneous auscultation and percussion of the abdominal wall, and ultrasonographic examination. The diagnosis of the DA was confirmed by laparotomy. All the cows with the DA were examined at Selcuk University Faculty of Veterinary Medicine Large Animal Clinic. Cattle with the DA were between the 1th and 4th weeks of lactation and were 2.5 to 8 years old. The control group of the study consisted of 10 healthy dairy cattle in early lactation.

Collecting blood samples

Jugular venous blood samples were taken from the cattle included in the study for haematological (K2EDTA tubes), blood gases (heparinized syringes) and serum biochemical analyses (serum tubes). After the blood samples taken for serum were kept at room temperature for 15 minutes, they were centrifuged at 5000 rpm for 10 minutes and their serum was removed, and the serum samples were stored at -80°C until measurement. Jugular venous blood samples were taken from the cattle included in the study for haematological (K2EDTA tubes), blood gases (heparinized syringes) and serum biochemical analyses (serum tubes). After the blood samples taken for serum were kept at room temperature for 15 minutes, they were centrifuged at 5000 rpm for 10 minutes and their serum was removed and the serum samples were stored at -80°C until measurement. White blood cell (WBC), red blood cell (RBC), haemoglobin (HGB), haematocrit (HCT), mean corpuscular volume (MCV), mean cell haemoglobin concentration (MCHC) and platelet values were determined from the blood samples taken into K2EDTA tubes within 30 minutes by using an automatic cell counting device (Medonic CA 530 Thor).

Blood gases analyses

Blood pH, partial pressure of carbon dioxide (pCO2), partial pressure of oxygen (pO2), sodium (Na+), potassium (K+), ionized calcium (iCa+2), bicarbonate (HCO3−), total carbon dioxide (TCO2), base excess (BE), oxygen saturation (SATO2), and lactate levels were measured from heparinized blood samples using a blood gas analyzer (GEM Premier Plus).

Blood gases analyses

From serum samples, insulin, glucose, fructosamine, cholesterol, triglyceride, very low-density lipoproteins (VLDL), non-esterified fatty acid (NEFA), beta-hydroxybutyric acid (BHBA), total protein, creatinine, aspartate aminotransferase (AST), gamma-glutamyl transferase (GGT) and creatine kinase (CK) values were measured using an autoanalyzer (BS 200, China).

Statistical analysis

Data were given as mean and standard error of the mean. Independent t test (SPSS for Windows) was used to determine the difference between groups in the study. P <0.05 was considered statistically significant.

Results

The cattle with DA had anorexia, weakening and defecation abnormalities. In addition, rumen contraction frequency and milk production were decreased.

When the haematological parameters between the groups were examined, no significant difference was found apart from the haematocrit value (Table 1).

Table 1. Haematological parameters in cattle with displacement of the abomasum (Mean±SEM)

Parameters	Control n=10	DA n=80	P
pH	7.41±0.01	7.45±0.01	0.003
pCO2 (mmHg)	41.90±2.24	41.77±0.98	0.957
pO2 (mmHg)	32.60±1.05	33.77±0.90	0.405
Na^+ (mmol/L)	143.30±1.19	139.30±0.54	0.009
K^+ (mmol/L)	3.91±0.08	3.01±0.07	<0.001
iCa^{+2} (mmol/L)	0.90±0.04	0.76±0.02	0.006
Lactate (mmol/L)	0.40±0.06	2.61±0.26	<0.001
HCO_3^- (mmol/L)	27.89±0.89	29.59±1.07	0.230
TCO_2 (mmHg)	28.50±1.56	30.45±1.03	0.314
BE (mmol/L)	2.90±0.80	4.60±0.97	0.185
$SATO_2$ (%)	68.20±1.88	65.24±1.74	0.257
WBC ($10^3/mm^3$)	8.30±0.50	9.79±0.60	0.064
RBC ($10^6/mm^3$)	6.52±0.28	6.99±0.16	0.163
HCT (%)	29.40±1.02	33.07±0.56	0.007
HGB (g/dl)	10.53±0.30	10.89±0.20	0.335
MCV (fl)	44.79±1.63	47.71±0.59	0.120
MCHC (g/dl)	36.04±1.18	33.49±0.63	0.075
PLT ($10^3/mm^3$)	626.40±61.52	496.18±48.13	0.109

pCO2; partial pressure of carbon dioxide, pO2; partial pressure of oxygen, Na+; sodium, K+; potassium, iCa+2; ionized calcium, HCO3-; bicarbonate, TCO2; total carbon dioxide, BE; base excess, SATO2; oxygen saturation, WBC; white blood cell, RBC; red blood cell, HCT; haematocrit, HGB; haemoglobin, MCV; mean corpuscular volume, MCHC; mean cell haemoglobin concentration, PLT; platelet

In blood gas analyses, it was determined that Na+, K+ and iCa+2 concentrations decreased significantly in cattle with abomasum displacement compared to the control group, while venous pH and lactate levels increased significantly.

When serum biochemical parameters were examined, plasma BHB, insulin, glucose, NEFA, triglyceride, VLDL concentrations and GGT, CK enzyme activities increased significantly, while cholesterol and total protein concentrations decreased significantly in cattle with abomasum displacement compared to the control group was determined (Table 2).

Discussion

It has been stated that haemoconcentration can be observed in dairy cattle with DA due to the trapping of the fluid in the displaced organ and the prevention of its transport to the duodenum, and the decrease in food and water intake (Ward et al., 1994; Dezfouli et al., 2013; Basoglu et al., 2020). Dezfouli et al (2013) indicated that a significant increase in haematocrit value in cattle with LDA can be attributed to haemoconcentration and dehydration. Similarly, in the present study, the HCT value was found to be higher in cattle with DA compared to the control group, and this was thought to be related to dehydration.

While blood pH and bicarbonate concentration increase in abomasum displacements, urine pH is generally acidic (Smith, 2009). In studies (Dezfouli et al., 2013; Song et al., 2020), it was also stated that Na+, K+ and Ca+2 levels decreased significantly in cattle with left abomasum displacement compared to healthy ones. Hypokalaemia is a common finding in abomasum displacements (Fubini et al., 1991; Smith, 2009). It has been stated that hypokalaemia may be caused by metabolic alkalosis and anorexia (Smith, 2009). In the present study, it was determined that venous blood pH was significantly higher and Na+, K+ and iCa+2 levels were significantly lower in cattle with displacement of the abomasum compared to the control group (Table 1). These results support previous studies.

It has been stated that a decrease in total protein and albumin levels is observed in cattle with DA, and this decrease may have developed following liver damage (Dezfouli et al., 2013; Basoglu et al., 2020; Song et al., 2020). Similarly, in the present study, serum total protein levels were found to be significantly reduced in cattle with DA compared to the control group.

In the periparturient period, some biochemical parameters (metabolic profile test) are used to evaluate the nutrition and health status of cattle and to determine some subclinical diseases (abomasal displacement, ketosis). It is stated that serum GGT and AST enzyme activities may be useful in the evaluation of liver function in cattle with abomasum displacement (Sevinc et al., 2002). In studies (Civelek and Sevinç 2003; Guzelbektes et al., 2010; Klevenhusen et al., 2015), it was stated that there was an increase in serum GGT and AST enzyme activities in cattle with abomasal displacement, and this increase was due to fatty liver. In the present study, it was determined that AST and GGT levels were higher than the control group, but only GGT activity increased significantly, and it was evaluated that this increase could possibly be related to fatty liver (Table 2).

Hamana et al. (2010) stated that there is a negative energy balance in cattle with left displacement of the abomasum, but that amino acid metabolism and protein synthesis are at normal levels.

Table 2. Metabolic parameters in cattle with displacement of the abomasum (Mean±SEM)

Parameters	Control n=10	DA n=80	P
BHBA (mmol/L)	0.53±0.05	1.37±0.10	<0.001
NEFA (µmol/L)	75.40±3.99	111.37±4.99	<0.001
Insulin (µU/ml)	8.39±0.47	10.85±0.36	<0.001
Fructosamine (µmol/L)	497.60±19.97	490.32±9.76	0.748
Glucose (mg/dl)	57.10±1.47	88.46±5.10	<0.001
Triglyceride (mg/dl)	8.90±0.67	14.10±0.51	<0.001
Cholesterol (mg/dl)	135.30±15.04	90.84±4.08	0.017
VLDL (mg/dl)	1.70±0.15	2.78±0.11	<0.001
Creatinine (mg/dl)	1.05±0.05	1.15±0.04	0.146
Total protein (g/dl)	6.60±0.15	6.23±0.09	0.045
AST (U/L)	27.00±1.72	30.81±2.76	0.246
GGT (U/L)	29.20±3.23	49.18±3.72	<0.001
CK (U/L)	198.20±25.87	657.82±84.03	<0.001

NEFA; non-esterified fatty acid, BHBA; beta-hydroxybutyric acid, VLDL; very low-density lipoproteins, AST; aspartate aminotransferase, GGT; gamma-glutamyl transferase, CK; creatine kinase

Sevinç et al. (2003) stated that there were significant changes in lipid and lipoprotein levels in cattle with fatty liver, and triglyceride, VLDL, albumin, total cholesterol and low-density lipoprotein levels were significantly lower in groups with fatty liver. Similarly, Civelek and Sevinç (2003) reported that blood cholesterol, HDL and LDL levels decreased in cattle with abomasum displacement compared to the control group. It has been reported that reduction in cholesterol (especially cholesterol esters), phospholipids and triglyceride levels are characteristic findings in cattle with fatty liver (Herdt, 2000; Katoh 2002; Sevinç et al., 2003). It is stated that the majority of the plasma cholesterol level is composed of high-density lipoproteins (HDL cholesterol) and the disruption of HDL secretion from the liver as a result of adiposity contributes to hypocholesterolemia (Herdt, 2000). On the contrary, in some studies (Klevenhusen et al., 2015; Song et al., 2020), it was determined that left displacements of the abomasum did not affect cholesterol levels. In the present study, it was determined that the cholesterol level of cattle with abomasal displacement was significantly reduced compared to the healthy ones, and it was evaluated that this situation could possibly be due to fatty liver. In addition, in the present study, serum triglyceride and VLDL concentrations were found to be significantly higher in the abomasal displacement group than in the control group. However, studies have shown that triglyceride and VLDL results in cattle with abomasal displacement are inconsistent. Civelek and Sevinç (2003) indicated that blood triglyceride and VLDL levels decreased in cattle with abomasum displacement compared to the control group. On the contrary, Durgut et al. (2016) found that triglyceride levels increased in cattle with abomasum displacement compared to the control group. While the results of our study were similar to the study of Durgut et al. (2016), it was not found to be compatible with the study of Civelek and Sevinç (2003).

Cattle with DA have high blood lactate value. This increase may be related to a decrease in abomasal tissue perfusion (Grünberg et al., 2005; Yurdakul and Aydoğdu 2018). In the present study, it was observed that the serum lactate level increased significantly in DA group compared to the control group (Table 1). This increase is probably related to insufficient perfusion of abomasal tissue. Another result that may support this is CK activity. An increase in serum CK is generally considered to be due to damage to skeletal muscles (Table 2). In addition, AST activity is not liver specific, and an increase in muscle damage can be observed (Constable et al., 2018). Sattler and Fürll (2004) thought that an increase in blood CK levels was observed in cows with DA and this increase might be related to abomasal damage. According to research by Fürll (2002), it has been reported that the abomasal wall (24641 U/g protein) shows second-order CK activity after skeletal muscle (62343 U/g protein), and also has more CK activity than cardiac muscle (8925 U/g protein). These results suggest that CK increase in cattle with DA patients may be associated with abomasal damage.

Findings regarding glucose and insulin levels in cattle with DA are inconsistent. While some studies (Zadnik, 2003; Dezfouli et al., 2013) have been reported that an increase in blood glucose level in cattle with DA, it was stated that there was no significant change in some studies (Stengarde et al., 2010; Song et al., 2020). The exact mechanism by which DA causes hyperglycemia is unknown. However, Zadnik (2003) has been reported that hyperglycemia may be associated with impaired outflow of pancreatic juice and impaired blood circulation in the pancreatic parenchyma due to changes in duodenal and omental position that occur during DA. Stengärde and Pehrson (2002) has been reported that high serum glucose concentrations may be related to stress. Guard (1990) has been suggested that hyperglycemia in cows with DA may be the result of transport, sudden environmental changes, or other stressors. In one study (Stengarde et al., 2010) that may support these results, the cattle included in the study were examined and sampled in their own herd, thus avoiding stress from changes in transport and feed and management. The results of the study (Stengarde et al., 2010) have been showed that DA may not cause consistent changes in plasma glucose concentrations. In the present study, blood glucose levels of cows with DA were found to be significantly higher than the control group (Table 2). This increase is probably related to the exposure of cattle with DA to stress factors such as transport, sudden environment, management and feeding (Guzelbektes et al., 2010) due to examination of cattle in the hospital setting. Pravettoni et al. (2004) have been reported that all 14 cattle with LDA had high glucose and insulin concentrations independent of ketosis at the time of admission to the hospital and could be attributed to insulin resistance. On the contrary, some studies (Stengarde et al., 2010; Song et al., 2020) indicatede that the blood insulin level in cattle with DA decreased significantly compared to the control group. Stengarde et al. (2010) stated that this decrease is most likely due to decreased feed intake. In the present study, insulin levels were found to be significantly higher in cattle with DA compared to the control group, supporting the results of Pravettoni et al. (2004).

Metabolites such as NEFA and BHBA are used to monitor energy balance in dairy herds. Seifi et al. (2011) stated that BHBA, NEFA and Ca concentrations in the early postpartum period are indicators for disease and remove from the herd. Metabolic profiles are also used to monitor herd health, investigate metabolic disorders, and predict the risk of ketosis and DA. It has been reported that an increase in serum BHBA level in the 2nd week after birth may cause an increase in the risk of DA and ketosis (Sen et al., 2006). Displacement of the abomasum is frequently observed in high-yielding cows and most of them occur within the first month (Chapinal et al., 2011). During this period, the energy requirement is high and negative energy balance (NEB) develops following the decrease in dry matter intake. There is an increase in NEFA and BHBA levels in cows developing NEB, and it has also been reported that this is a risk factor for LDA (Song et al., 2020; Zadnik, 2003; Chapinal et al., 2011; LeBlanc et al., 2005). In a recent study (Song et al., 2020), it was determined that there was a strong increase in serum NEFA and BHBA levels in cows with LDA. In the present study, which is similar to other studies, the NEFA and BHBA values of cows with DA were found to be significantly higher than the control group (Table 2).

Conclusions

In conclusion, it was observed that DA was associated with negative energy balance, liver damage, electrolyte disturbances and hemoconcentration. Detection of hematological, blood gases and metabolic parameters in cows in the periparturient period can provide information about metabolic diseases like DA on an individual or herd basis.

Acknowledgements

Presented in part in abstract form at the 11. Veterinary Internal Diseases Congress Samsun, Turkey, May 21-24, 2015. This work was supported by the Sivas Cumhuriyet University Scientific Research Projects Coordinator.

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