RESEARCH ARTICLE

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Evaluation of Rumination Behavior in Cows Before and After Surgical Correction of Left Displaced Abomasum

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Abstract

The aim of this study was to investigate the rumination behavior of cattle in the diagnosis of left displaced abomasum (LDA) and in the surgical correction process. In 6 cows diagnosed with LDA, surgical abomasopexy was performed via left-flank laparotomy. The cow monitoring system attached to the neck of each animal was used to monitor the rumination times. Rumination data were evaluated over a 35-day period covering the healthy period, diagnosis and treatment of LDA. In the healthy period (control group), the mean rumination time of the animals was determined as 508.74±8.52 mins. In the preoperative period, the mean rumination time was determined as 335.57±16.29 mins (-14 and -8 days) and 234.48±13.83 mins (-7 and -1 days) and a statistically significant decrease was determined compared to the healthy period ($p<0.001$). In the first postoperative week, the rumination time showed a significant increase (393.57±26.9 mins) and in the second postoperative week, the results were similar to those of the healthy period (501.21±17.29 mins). This is the long-term study to have evaluated the change in preoperative and postoperative (35-day period) rumination in cattle diagnosed with LDA. The results demonstrate that rumination behavior is an important marker in the early diagnosis and follow-up of the postoperative prognosis of diseases causing economic loss, such as abomasum displacement.

Keywords: Abomasopexy, cattle, dairy cows, displaced abomasum.

INTRODUCTION

Left displacement of the abomasum (LDA) generally occurs postpartum in high yielding dairy cows (Ismael et al., 2018). The incidence of postpartum LDA has been reported to be mean 7% with a wide range of 0% - 25%. The displaced abomasum (DA) incidence in dairy herds in the USA was approximately 3.5% in 2017, and it has been reported as 4.8% in herds of fewer than 500 animals (Caixeta et al., 2018; Mueller 2011). Therefore, the economic losses due to LDA have become increasingly important (Mueller, 2011). In LDA, the abomasum fills with fluid, gas, or both, and with the prevention of passage as it is full, shifts to the left side of the abdominal cavity.

Abomasal hypotonia or atonia and distension of the abomasal fundus are preparatory causes (Niehaus, 2016; Caixeta et al., 2018), and predisposing factors include sex, age, increased parity, periparturient migration of abdominal organs, twin pregnancy, stillbirth, breed, and various diseases (Caixeta et al., 2018; Janovick et al., 2011). LDA is seen more often than displacement to the right. Surgical treatment of LDA is common in lacting dairy cattle (Doll et al., 2009; Antanaitis et al., 2015).

Rumination is a cyclical process characterized by regurgitation, remastication, and reswallowing (Beauchemin, 1991). This process is variable and is affected by several factors, primarily acute stress, disease, diet composition and the quality of the feed, and management errors (Smith et al., 2018). Behavior, reproductive status, yield level, climate change, and health status cause variability in cud number. There has been reported to be a change in cud number following surgical correction of cows determined with LDA. King et al., (2017) reported a change in rumination time before displacement diagnosis with an automated milking system. Therefore, knowing the change in rumination time is important in respect of early diagnosis of diseases. Automated health-monitoring systems that shows rumination information are capable of identifying animals with metabolic and digestive disorders earlier than clinical diagnosis by farm personnel (Stangaferro et al., 2016). Various methods have been developed to automatically record changes in the feeding and/or rumination of cattle (Nydegger et al., 2011; Schirmann et al., 2009; Braun et al., 2015; Braun et al., 2014). In the current study, the daily rumination time was monitored with the SenseHub (SCR-Allflex) device.

LDA causes milk losses. It has been reported that there may be milk loss of 30% in the period up to LDA diagnosis (Detilleux et al., 1997). Moreover, the greatest milk losses associated with LDA have been shown to be in the highest yielding cows (Kang et al., 2019).

Abomasum displacement occurs after calving and is seen most often in the 14 days postpartum. In pregnancy, the uterus takes the place of the abomasum and returns to its orginal position after calving. In this period, atonia can develop in the abomasum, and with a reduction in contractions, gas accumulates in the abomasum and displacement occurs. Treatment with operative intervention is possible in displacement, but there may be negative outcomes in some cases. Therefore, in the management of LDA, economic losses must be taken into consideration such as treatment costs, reduced milk yield, and removal from the herd by sale or slaughter (Kang et al., 2019; Nikkhah et al., 2021).

Therefore, it is important to establish strategies for the prevention and early diagnosis of displacement,

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especially in high yield dairy herds. From a scan of literature, there was found to be only one study about DA surgical treatment and rumination habits (Braun et al., 2015). The aim of the current study was to investigate the change in rumination time from before LDA diagnosis to after treatment. In the study by Braun et al (Braun et al., 2015) data of a 5-day period were evaluated and in the current study, the data were evaluated of a 35-day period, covering the healthy period, LDA diagnosis, surgical treatment and the postoperative period.

MATERIALS AND METHODS

Animals

The study involved 6 dairy cows (Holstein). The study was conducted on the Arif Gürdal Dairy Farm with the approval of ADÜ- HADYEK (64583101/2022/004). A preliminary diagnosis of LDA was made on the basis of physical examination findings (simultaneous percussion and auscultation of the left side of the abdomen), and the diagnosis was confirmed during surgery. Urine test strips (Keto-Diastix, Bayer, Germany) were used for ketosis examination.

Surgery Technique

Left flank laparotomy was choosed for the abomasopexy. The abomasopexy was performed as described by Fubini and Ducharme (Fubini, 2004) The left flank was clipped and aseptically prepared. The local anesthesia was administered as an infiltration of a 2% solution of lidocaine (60 mL, Adokain, Sanovel). The procedure was performed with the cow standing. The location for the skin incision was centered over the paralumbar fossa, ventral to the transverse processes of the lumbar vertebrae and caudal to the last rib. The incision was made in a dorsoventral direction (Figure 1). The inner abdominal oblique muscle layer was cut in the same way as the outer abdominal oblique in the direction of the muscle fibers.

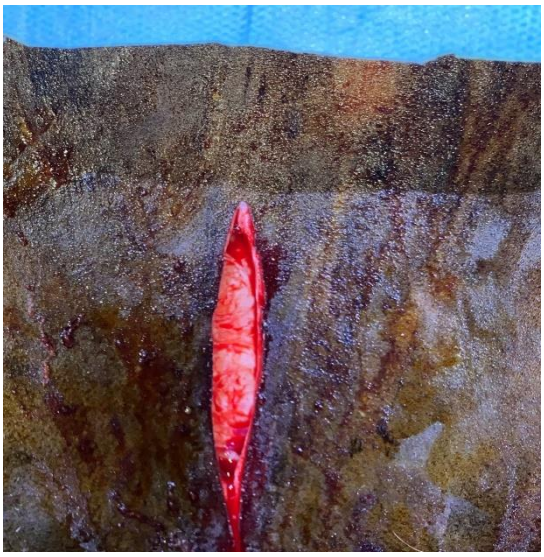

Figure 1. Left flanks dorsoventral incision.

The LDA was visualized (Figure 2), and multiple continuous suture of a non-absorbable material (fishing line) were placed in the greater curvature of the abomasum (Figure 3). The ends of the suture were left protruding from the abomasum equally at the ends of the suture line and were then passed ventrally along the left body wall, across the midline to emerge through the abdominal wall at the external abdomen. An assistant guided the surgeon both suture ends were passed thought the ventral body wall before the abomasum was replaced in the normal position (Figure 4).

Figure 2. Black arrow: displaced abomasum, white arrow: rumen.

Figure 3. The greater curvature of the abomasum, arrow: fishing line.

Figure 4. The suture ends.

A 14-gauge needle attached to a flexible tube was inserted into the dorsal aspect of the abomasal lumen, and the other end of the tube was placed in a cup full of water to decompress the gas accumulated within the DA. This process prevented the outside air from entering while the gas was being discharged from the abomasum.

The abomasum was pushed ventrally by the surgeon as the assistant pulled the excess suture tight. Once the abomasum was successfully replaced, the assistant tied the sutures externally to fix the abomasum in position.

The peritoneum and transversus abdominis were sutured with absorbable suture material (USP2, Vicryl, ETHICON, USA) in a simple continuous pattern. The internal abdominal oblique and external abdominal oblique muscles were closed separately with simple continuous sutures. The skin was closed with interrupted sutures (USP 2, Silk, ETHICON, United States).

Data collection

The SenseHub sophisticated modular cow monitoring system (SCR Allflex) attached to the neck of each animal (Figure 5) was used to monitor the rumination times in minutes as recorded automatically in the system. The data of 35 days were divided 5 time periods, every time period contain 7 days. The data of 7 days of the healthy period of each cow were obtained as normal rumination times as time period 1 (control group). Operation day was defined as day 0. Time period 2 was defined as day -14 to day -8 before the treatment of LDA with abomasopexy, and time period 3 as day -7 to day -1. Time period 4 was from day 0 to postoperative day 6, and time period 5 was from postoperative day 7 to day 13. Thus, the data were collected for a total period of 35 days in groups of 7 days (Table 1).

Figure 5. Neck tag of the cow monitoring system.

Table 1. Explanation of the time periods and groups.

	Healthy	Preop	Preop	Op	Postop	Postop
d	7 days	-14 -13 -12 -11 -10 -9 -8	-7 -6 -5 -4 -3 -2 -1	0	1 2 3 4 5 6	7 8 9 10 11 12 13
Group	1	2	3	4		5

Pereop: preoperative, Op: operation, Postop: postoperative.

Statistical analyses

Results were evaluated with Shapiro-Wilk Test & Q-Q Plot for normality and Mauchly's Test for sphericity assumptions. To compare same 6 cows in different conditions, we used One-Way Repeated Measures (within-participants) ANOVA and followed by the Bonferroni post hoc tests were used for pairwise comparations among all periods. Results are summarized in table as mean±standart error. The data were analyzed using IBM SPSS Statistics (v26) predictive analytics software. Differences with $p<0.05$ were considered to be statistically significant in all tests.

RESULTS

The animals included in the study were at 19-24 days postpartum. All the animals had a reduction in appetite, dehydration of varying degrees, and loss of fecal texture. Moderate and over-ketosis was diagnosed in all the cows. In auscultation and percussion between the 9th and 13th costae on the left side of the abdomen, a hyper-resonant 'ping' sound was obtained. The LDA diagnosis was confirmed in the operation of all 6 cows. During the operation a change was determined in abomasum serosa. Visceral examination extended as far as the reticulum and no abnormality was determined.

No complications were encountered during the operation. Postoperatively, an increase was observed in food intake and rumination time. The mean rumination time of the animals in the healthy period was 508.74±8.52 mins. A significant decrease was determined in rumination times in the preoperative 2nd and 3rd time periods (335.57±16.29 mins and 234.48±13.83 mins, respectively). The value in the 4th time period (393.57±26.9 mins) showed a significant difference from the values of the 1st, 3rd, and 5th periods ($p<0.001$). The time measurement in the 5th period was similar to that of the healthy 1st period (Figure 6, Table 2).

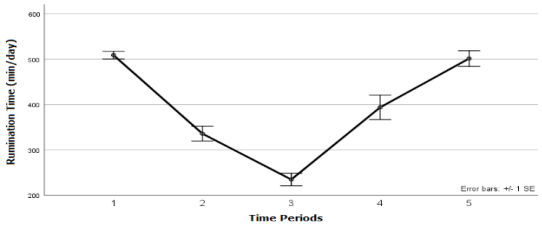

Figure 6. Rumination times in periods.

Table 2. The rumination times (mins/day) of the 6 cows over the 35-day period.

Time Period	Mean±SE	95% CI [LL, UL]	P
1	508.74±8.52[a]	[491.5, 526]	
2	335.57±16.29[b]	[302.7, 368.5]	
3	234.48±13.83[c]	[206.546, 262.4]	<0.001
4	393.57±26.9[b]	[339.25, 447.9]	
5	501.21±17.29[a]	[466.288, 536.1]	

a, b, c: The difference between rumination times in the same column is statistically significant.

DISCUSSION AND CONCLUSION

DA is routinely determined and treated on dairy farms. Farm workers determine reductions in appetitie and yield, and veterinary surgeons make the diagnosis from a "ping" sound on percussion and auscultation. Ideally, the veterinary surgeon prefers to correct the DA with surgery (Baird, 2012). A sudden drop in feeding and rumination activity in a single cow indicates disease (Braun et al., 2014). The feeding and rumination behavior of cattle is of clinical importance for the veterinary surgeon as observation of these behaviors has prognostic value in diagnosis and the treatment process. It is difficult to observe the feeding and rumination behavior of animals separately in a large herd. However, with technological developments, systems have started to be used that measure and record these behaviors every 2 hours, and then process the data in a computer environment and convert the results to graph form (Braun et al., 2013).

Previous studies have examined the feeding and rumination behavior in cattle. The accuracy of sensor recordings has been confirmed with direct observation of feeding and rumination in one day (Braun et al., 2013; Braun et al., 2015; Braun et al., 2014) Daily variations of changes in feeding and rumination are of great importance for the evaluation of the health status of a cow.

LDA is a common disease in periparturient dairy cows (Zurr and Leonhard-Marek, 2012). Health disorders such as ketosis and DA that occur in the early postpartum period of lactating cows have a negative effect on the welfare, yield, and health of the animals (Vercouteren et al., 2015). A ping sound obtained on percussion and auscultation on the left side confirms left-side displacement of the gas-distended abomasum (Niehaus, 2016). In this study, the diagnosis was similarly confirmed and all 6 cows were ketosis-positive. Urine tests and blood tests show almost the same performance in the diagnosis of ketosis (Faruk et al., 2020). Urine strips were used in the current study as they are non-invasive and easy to apply.

Previous studies have documented reductions in milk yield in cows with ketosis and DA at earlier than 5 days before clinical diagnosis (Leblanc, 2010; Edwards and Tozer, 2004; King et al., 2017). In the current study, as the diagnosis day was d-3 day, the previous 5 days were included. Thus, the period starting from d-1 to d-7 was determined as the 3rd time period.

It has been reported that rumination is significantly lower in cows with LDA compared to healthy control animals, and within 5 days after treatment, there is a significant increase in the number of ruminations together with an improvement in the general condition of the cow (Braun et al., 2015; Braun et al., 2014). King et al., (2017) reported that the rumination time of 5 cows determined with DA showed a decrease from -12 days before diagnosis to the day of diagnosis. In this study, a statistically significant decrease was recorded in the 2nd and 3rd time periods compared to the data of the healthy period of the 6 cows. In the 4th time period postoperatively, a significant increase was observed in the rumination times, and the times recorded in the 5th period were similar to those of the healthy period.

In the light of previous studies and this result of the current study, it can be considered that changes in rumination times recorded with automatic herd monitoring systems could be useful in early diagnosis and the success of treatment. Stangoferro et al (Stangaferro et al., 2016) stated that they observed the greatest sensitivity in rumination time for cattle that developed DA, and intermediate sensitivity for cattle with ketosis. Rumination time is affected in metabolic diseases such as ketosis, and in cases with ketosis and displacement, it has been reported that there could be ketosis present before the diagnosis of displacement (Stangaferro et al., 2016; Leblanc, 2010).
The selection of the technique to be used is affected by factors such as application of the method on the farm, the unavailability of laparascopic instruments, and familiarity of the surgeon with the method.

Methods used in the surgical treatment of abomasum displacement are: (Baird, 2012)

- ✓ Right: Omentopexy, pyloricantropexy ("pyloropexy"), right paramedian abomasopexy
- ✓ Left flank abomasopexy
- ✓ Rolling: "Roll and tack" or "Roll and toggle"
- ✓ One-step or two- step laparoscopic abomasopexy

Right flank techniques are preferred by surgeons as they present advantages for abdominal exploration and working alone (Niehaus, 2016).

In right flank omentopexy, the abdomen is reached with an incision made from the right fossaparalumbar region, and the omentum majus attaching to the grater curvature of the abomasum is fixed to the right body wall. When sutures are passed from the omentum and are not sufficiently close to the pylorus, displacement may develop again. Not placing any sutures in the abomasum removes the risk of peritonitis associated with abomasal content leakage. Displacement may occur again as a result of retraction and fragmentation as the omentum is a friable structure. Some surgeons prefer to perform pyloropexy together with omentopexy. Pyloropexy is generally preferred in conditions where omentopexy will be insufficient.

If sutures passing from the pyloric antrum of the abomasum pass from the muscular pyloris, pyloric structure and outflow problems may develop. It has been reported that recurrence may be seen more in LDA cases applied with omentopexy alone compared to those applied with pyloro-omentopexy (Baird et al., 2017).

There are studies in literature showing that laparoscopic methods are more appropriate than laparotomy (Haloun et al., 2020; Wittek et al., 2009; Fiore et al., 2018; Çeçen Ayalp et al., 2020; Temizsoylu et al., 2010; Özsoy et al., 2012). Minimally invasive techniques are more rapid than traditional open approaches, cause less muscle destruction, and allow less use of antimicrobials. The main disadvantages are the need for laparoscopic equipment, more than one surgeon, and hospital conditions (Perotta et al., 2018; Babkine et al., 2006) The disadvantage of a right flank approach is that a view of abomasal ulcer or peritonitis is not possible in complicated LDA cases (Niehaus, 2016).

Omentopexy is a procedure in which the omentum majus attached to the greater curvature of the abomasum is fixed to the right abdominal wall, keeping the abomasum close to the anatomical position.

Left flank abomasopexy is used for the correction of LDA alone, and should therefore be selected when there is certainty of the diagnosis. When the abdomen is reached, the rumen may restrict the visual field of the surgeon and this makes the visceral exploration more difficult. In contrast to right flank approaches, a left flank method requires an assistant to be able to make the pexy in the correct position by providing passage of the needle from the ventral abdominal wall. In cases with left abdominal

wall adhesions of the abomasum, left flank abomasopexy provides an advantage. It provides the opportunity for determination and repair of abomasal lesions such as ulcer and perforation. In cases of LDA forming during pregnancy, the visual field of the uterus is restricted in right flank approaches and therefore, left flank is more preferred.

The industrialisation of livestock farming has brought herd management and monitoring systems into more widespread use. It is very clear that the automatic recording of individual feeding and rumination activities provides savings of time and labour. The opportunity for early diagnosis and follow-up of treatment with monitoring of rumination habits in diseases such as DA has been proven in the current study and in other previous studies. (Braun et al., 2015)

No clear optimal surgical treatment has been defined to date (Baird, 2012). The technique selected depends on the surgeons preference to a great extent, the help available, the value and purpose of the cow, the direction of the displacement, the presence of adhesions, and previously surgically corrected displacement. Cattle with surgical correction of uncomplicated abomasal displacement have a good and excellent prognosis for a return to productivity. (Pentecost et al., 2014; Niehaus, 2016)

To sum up the rumination time changes are significant as they allow to quickly find cows from the risk group to suffer from LDA due to decrease in rumination almost two weeks before diagnosis. These results may be used as an example or pattern how rumination frequency should return to normal level after the surgical treatment.

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Conflict of Interest
The authors declare that they have no competing interests.

Authorship contributions
Concept: B.K.K., Data Collection or Processing: B.K.K., Analysis or Interpretation: B.K.K., Literature Search: B.K.K., M.S., Writing: B.K.K., M.S.

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