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REPRODUCTIVE SYSTEM CONDITION IN DAIRY COWS WITH LEFT-SIDED DISPLACEMENT OF THE ABOMASUMS

Piotr Brodzki[1♦], Adam Brodzki[2], Łukasz Kurek[3], Jan Marczuk[3], Marcin R. Tatara[4]

[1]Department and Clinic of Reproduction,
[2]Department and Clinic of Animal Surgery,
[3]Department and Clinic of Internal Medicine, Faculty of Veterinary Medicine,
University of Life Sciences in Lublin, Głęboka 30, 20-612 Lublin, Poland
[4]Department of Animal Physiology, Faculty of Veterinary Medicine,
University of Life Sciences in Lublin, Akademicka 12, 20-950 Lublin, Poland
♦Corresponding author: wetdoc@interia.pl

Abstract

The aim of the study was to evaluate selected parameters representing reproductive system conditions in cows suffering from left-sided displacement of the abomasum (LDA). Eighty Holstein-Friesian cows were divided into control (n=40) and LDA (n=40) groups. Haematological and biochemical evaluations were performed in the control group and in cows with LDA before and after surgical treatment. Cytological and ultrasound examinations of the uterus were performed at 21 (baseline), 35 and 63 days after parturition. In the LDA group, significantly decreased concentrations of calcium, magnesium, phosphorus, copper, potassium, glucose and total cholesterol were stated, while aspartate aminotransferase activity, white blood cell count, erythrocyte count, haematocrit, haemoglobin content and concentration of β-hydroxybutyrate, free fatty acids and bilirubin were increased (all P<0.05). Percentage of neutrophils in the uterus and the uterus diameter were increased in the LDA group at the baseline and at 35 days after parturition (P<0.001). The neutrophil percentage was also increased at 63 days after parturition in the LDA group (P<0.001). Number of days to first oestrus, number of services per conception and calving-to-conception interval were higher in the LDA group (P<0.001). This study has shown reproductive system changes and impaired fertility in dairy cows as the consequence of LDA occurrence. Thus, LDA treatment in cows should be combined with diagnostic evaluation of the uterus and reproductive system to improve reproductive performance. As indicated in the cytological examination, a subclinical inflammatory process may last even 60 days after parturition, leading to substantial impairment of reproductive function in dairy cows.

Key words: cow, left-sided displacement of the abomasum, uterus, fertility

Left-sided displacement of the abomasum (LDA) in dairy cows is a disorder that has long been known and described (Lowe et al., 1965; Ames, 1968; Janowitz, 1998). In recent years, however, a significant increase in its incidence has been

observed. Use of high-energy feeds tailored for high milk production, with small amounts of roughage is considered to be the main cause of abomasal displacement (Shaver, 1997; Van Winden et al., 2003; Goff, 2006). Moreover, the start of lactation and accompanying sudden substantial loss of vitamins and minerals, protein, fats, glucose, and other substances, which even the most intensive feeding cannot replenish, leads to displaced abomasum as well as many other disorders, including metabolic disturbances. The loss of these substances, which causes metabolic disorders, is the most important change predisposing cows to the displacement of the abomasums. Mineral metabolic disorders, especially hypocalcaemia, lead to reduced muscle contractility, including the smooth muscles of the digestive tract and uterus. Atony of the abomasum and gas accumulation within it is the direct cause of its displacement, usually to the left side of the abdominal cavity (Massey et al., 1993; Van Winden and Kupier, 2003; Zadnik, 2003; Constable et al., 2013). Within a short time, feed uptake by the cow is reduced, milk production decreases sharply, and associated disorders occur, such as metabolic alkalosis, negative energy balance and ketosis, and, at a later stage, liver damage (Geishauser et al., 1997; Herdt, 2000). Exacerbation of clinical symptoms and the appearance of associated disorders depend on how quickly the displaced abomasum is diagnosed and treatment started. Treatment of LDA involves restoring the proper position of the abomasum in the abdominal cavity and fixing it to the abdominal wall in order to prevent recurrence of the problem. Prompt diagnosis and proper medical procedure virtually guarantee successful treatment, reducing economic losses associated with long-term treatment and maintaining a good body condition and high productivity in the cow. Since the first time that diagnosis of displaced abomasum has been described, tremendous advances have been made over time in diagnosis and treatment methods, so that the effectiveness of treatment and the percentage of cows that are cured have continually increased (Rager et al., 2004; Newman et al., 2005; Roy et al., 2008). Development of disorders associated with, or accompanying, abomasal displacement is of fundamental importance in this condition. Proper functioning of the reproductive system and likelihood of pregnancy is one of the fundamental conditions for the raising of dairy cows and its profitability. Further reproductive ability of cows with LDA is generally unknown. Some authors have observed retained fetal membranes accompanying LDA, which is linked to reduced contractility and impaired involution of the uterus, as in the case of abomasal atony (Vlaminck et al., 2000; Wittek et al., 2007). These disorders can lead to endometritis, which is also often described during LDA (Van Winden and Kupier, 2003; Sexton et al., 2007). Fertility disorders can best be determined based on evaluation of basic reproductive parameters in the herd of an appropriately selected group of animals. The condition of the endometrium, both in the postpartum period and later on, can only be assessed on the basis of appropriate tests. One of these is endometrial cytology, based on which Sheldon created a new classification of uterine inflammations (Sheldon et al., 2006; LeBlanc, 2008). Cytological examination enables the fastest possible detection and treatment of cows with endometritis that has persisted for too long. The percentage of leukocytes visible in the smear is determined and the inflammatory state is ascertained depending on the time after calving. Endometritis is diagnosed 21–33 days after parturition when the

percentage of leukocytes exceeds 18% and between 34 and 47 days after parturition if the percentage exceeds 10%, while the appropriate amount of leukocytes should not exceed 5% after the postpartum period, from day 60 after parturition (Kasimanickam et al., 2004, 2005; Sheldon et al., 2006; Gautam et al., 2010). More recent studies on grazing dairy cows define subclinical endometritis by increased proportion of polymorphonuclear cells (PMN) in uterine cytology by 8–8.5%, 6–6.5% and 4% during these periods, respectively (Galvão et al., 2009; Madoz et al., 2013).

The aim of the study was to compare haematological (erythrocyte count; haematocrit value, haemoglobin concentration, and white blood cell count) and biochemical parameters (concentrations of calcium, magnesium, phosphorus, potassium, glucose, cholesterol, total protein, bilirubin and aspartate aminotransferase activity) of the blood of cows with LDA, before and after surgical treatment for the disorder, and to evaluate the coexistence of LDA with changes occurring in the reproduction system and reproductive indices in cows.

Material and methods

The study was conducted on 80 Holstein-Friesian (HF) cows. The experimental group consisted of 40 cows that had been diagnosed with LDA (LDA group). The control group consisted of 40 clinically healthy cows in the same physiological period as the cows with LDA. The cows were from 7 private farms with herds of 30 to 100 cows aged 3–6 years. All animals had a full veterinary examination performed according to standards (body temperature, respiratory rate, heart rate etc.). Control cows were age-matched to those cows with diagnosed LDA within each farm. Total number of animals selected for the LDA group from each farm varied between 4 and 8 cases, but the study was conducted throughout 3 lactation seasons. Total season incidence of LDA at each farm was between 0 and 8%, but only cows treated successfully were included in the study. Their body condition before the LDA diagnosis was good or very good (Body Condition Score 3.5–4.0), and they had produced over 35 litres of milk per day in the earlier lactation. Feeding was based on the TMR (Total Mixed Ration) system and included maize silage, grass silage, hay, straw, grain meal, soy meal, and mineral and protein supplements. When the cows became ill they demonstrated reduced appetite, diarrhoea, or absence of faeces. Some also demonstrated symptoms of pain in the form of shifting from limb to limb and flank watching, loss of lactation yield in varying degrees, and unwillingness to rise from the resting area. Left-sided displacement of the abomasum was diagnosed based on the medical history, clinical symptoms, and most importantly, a characteristic resonant sound (the "ping and pung effect") during simultaneous auscultation and percussion in the area of the rumen, on the left side of the abdominal cavity. In addition, no peristalsis of the abomasum could be heard on the side where it should be located. Following diagnosis of LDA, the cows were treated surgically by left flank omentopexy, a well-known and extensively described method (Ames, 1968; Rager et al., 2004; De Cardoso et al., 2008). Only successfully treated cows that remained in their

herds at least until the end of the study were chosen for the experiment. Cows with a poor prognosis or treated unsuccessfully were not included in the study (8 animals). All cows treated for LDA calved about 3 weeks earlier. In addition to the surgical treatment, adjuvant therapy was used following the procedure, in accordance with other studies (Vlaminck et al., 2000; Rager et al., 2004). Further treatment depended on disease symptoms and blood test results. Cows that continued to exhibit reduced appetite were given oral preparations containing propylene glycol and sodium propionate for 5 successive days. Blood samples for haematological and biochemical analyses were collected from the cows twice: at the onset of LDA and after treatment was completed – 2 weeks after the surgery. In the control group, blood samples were collected from the cows in the same physiological period as in the cows with LDA. Blood samples were collected from the external jugular vein into tubes with EDTA (Vacutest tubes, Vacutest Kima S.r.l., Arzergrande (PD), Italy) for haematological evaluation and for a clot to obtain serum for biochemical analysis. The haematological evaluation was conducted using an automatic blood counter (Vet Animal Blood Counter SCIL VET, Horiba ABX, Montpellier, France). Basic haematological parameters such as erythrocyte count, haematocrit (Ht) value, haemoglobin (Hb) concentration, and white blood cells (WBC) count (with leucogram) were evaluated. Concentrations of calcium, magnesium, phosphorus, potassium, glucose, cholesterol and bilirubin, as well as aspartate aminotransferase (AST) activity and total protein content in serum were determined by a colorimetric method and a diagnostic apparatus (Mindray, Bio-Medical Electronics Co., Ltd., Shenzhen, China). Copper concentration was determined by Perkin Elmer atomic absorption spectrophotometer (Perkin Elmer Co., Waltham, MA, USA). β-hydroxybutyrate (BHB) was determined using a commercial kit (Ranbut kit, Randox Laboratories Ltd., London, United Kingdom), while free fatty acids (FFA) were evaluated by titration.

The control of the reproductive system in the herd by rectal examination combined with ultrasonography was conducted regularly at monthly intervals. Cows with no complications during parturition and no signs of inflammation were applied the synchronization protocol of oestrus and ovulation (presynch-ovsynch protocol) and artificially inseminated (AI) with frozen semen. The cows with uterine inflammation were properly treated, and subsequently subjected to synchronization protocol of oestrus and ovulation and AI. The cows with ovarian cycle disturbances were treated individually according to the cause diagnosed. Examination of the reproductive system in each experimental cow included a rectal examination of the uterus and ovaries, and an ultrasound examination using ultrasonographic apparatus (Honda HS-1500, Honda Electronics Co., Ltd., Toyohashi, Japan). Cytological evaluation of the uterus was performed to monitor the condition of the endometrium. An ultrasound examination was performed to measure the diameter of the uterine horns in order to check the dynamics of uterine involution. The reproductive examinations were performed three times at various periods. The first examination was conducted immediately after LDA diagnosis (3 weeks after parturition – baseline). The second examination was two weeks later, after the LDA treatment had been completed (35 days after parturition), while the third examination was performed at 63 days after parturition. The cows in the control group were examined at the same intervals

after parturition. Endometrial cytology was performed using an endocervical cytology brush, specially adapted for cows (Jiangsu Yada Technology Group Co., Ltd., Jiangsu, China). The procedure for collecting the material was the same for all the experimental and control animals. After the catheter was passed through the cervix to the base of the uterine horn, the brush was released from the tube and rotated around its long axis within the uterus to collect the material to be examined. Insertion of the catheter and collection of material from the uterus were controlled by the other hand through the rectum. After a few rotations, the brush was retracted into the catheter and removed from the uterus. All elements used to collect the material were sterile. Cytological smears were made directly from the brushes as imprint specimens on microscope slides. After the smears were thoroughly dried, they were fixed and stained with the use of Hemacolor rapid staining (Merck KGaA, Darmstadt, Germany). Then the smears were examined under a light microscope at 1000× magnification (Olympus CX41 microscope, Olympus Co., Tokyo, Japan). A camera attached to the microscope sent the image to the computer so that the smears could be documented (Basler camera, Basler AG, Ahrensburg, Germany). The cytological evaluation was based on determination of the percentage of neutrophils in the smears. One hundred cells visible in different fields of view were counted in each smear. The percentage of neutrophils was determined as previously described (Kasimanickam et al., 2004, 2005).

Six months after parturition, the most important reproductive parameters such as calving-to-conception interval, services per conception and time of the first visible oestrus after parturition during this period were evaluated in both groups of cows.

Statistical analysis

The results obtained were analysed using statistical software (Statistica version 6.0, StatSoft, Inc., Tulsa, OK, USA). The values present means and standard deviations (±SEM). To determine statistical significance of the differences of the investigated variables between LDA and control group, non-paired Student's t-tests was applied. The comparison of statistical significance of the investigated variables within the LDA group (35 versus 21 days) was performed using paired Student's t-tests. P-value<0.05 was considered as statistically significant for all comparisons.

Results

The results of the biochemical and haematological indices are presented in Table 1. Significantly higher bilirubin concentration in blood was found in LDA group 21 days from parturition (baseline) when compared to the control group (P<0.001). In the LDA group, bilirubin concentration was significantly decreased at 35 days from parturition. Significantly lower cholesterol concentration in blood was stated in the LDA group at baseline when compared to the control group (P<0.001). In the LDA group, cholesterol concentration was significantly increased at 35 days from parturition when compared to 21 days (P<0.001). Aspartate aminotransferase activity was

significantly higher in the LDA group at 21 days after parturition when compared to the control group (P<0.001). In the LDA group, AST activity was significantly lower at 35 days from parturition when compared to 21 days (P<0.001). Glucose concentration was significantly lower in the LDA group at baseline when compared to the control group (P<0.001). Calcium and magnesium contents in the LDA group were found to be significantly lower at the baseline compared to the control group (P<0.001). In the LDA group, calcium and magnesium contents were significantly increased at 35 days from parturition when compared to 21 days (P<0.001). Phosphorus concentration in the LDA group was significantly lower at baseline when compared to the control group (P=0.01). Copper and potassium concentrations in the blood in the LDA group were found to be significantly lowered at baseline when compared to the control group (P<0.001). In the LDA group, copper and potassium concentrations in blood were significantly increased at 35 days from parturition when compared to the baseline values (P<0.001). β-hydroxybutyrate and FFA concentrations in the LDA group were found to be significantly higher at the baseline when compared to the control group (P<0.001). In the LDA group, BHB and FFA concentrations were significantly decreased at 35 days from parturition when compared to the baseline values (P<0.001). White blood cells and band neutrophil numbers were found to be significantly higher in the LDA group at the baseline when compared to the control group (P<0.001). In the LDA group, the WBC number was significantly lower at 35 days from parturition when compared to the baseline value (P<0.001). Erythrocytes count, Ht value and Hb concentration in blood were found to be significantly lower in the LDA group at 21 days from parturition when compared to the control group, respectively (P<0.05). In the LDA group, the erythrocyte count, Ht value and Hb concentration in blood were significantly decreased at 35 days from parturition when compared to the baseline values, respectively (P<0.05).

Per rectum examination in conjunction with USG showed an enlarged diameter of the uterus (Table 2) and fluid in the uterus. The majority of cows had mucopurulent vaginal discharge (70%). The number of neutrophils obtained as a result of cytological examination of uterus has reached significantly higher values at baseline and 2 and 6 weeks later in the LDA group, when compared to the control group, respectively (P<0.001). All cows from the LDA group had endometritis. There was no endometritis in healthy cows. The uterine diameter was found to be significantly higher at the baseline and 2 weeks later in the LDA group when compared to the controls (P<0.001); while the statistically significant difference of this parameter was not observed at 63 days after parturition (P>0.05). Among the cows with LDA were isolated cases (4 cows) which experienced milk fever after parturition, including retention of the placenta. There were no such cases in the control group.

Results of the analysis of the reproductive parameters in cows are shown in Table 3. Significantly longer periods between parturition and onset of first oestrus by the 26th day in cows from the LDA group were stated when compared to the controls (P<0.001). Number of services per conception was significantly (2.5-fold) higher in the LDA group when compared to the control group (P<0.001). Furthermore, the calving-to-conception interval was significantly longer (by nearly 45 days) in the cows suffering from LDA when compared to the controls (P<0.001). Cows with

endometritis, in the LDA group, after the end of the study (after 63 DPP) were adequately treated. All cows became pregnant six months after parturition.

Table 1. Biochemical and haematological parameters in blood collected from the control and LDA groups

Investigated parameter	Control group (n=40) 21 days from parturition – baseline	LDA group (n=40) 21 days from parturition – baseline	LDA group (n=40) 35 days from parturition
Bilirubin (μmol/l)	6.50±2.74	18.13±9.75*	8.38±3.25##
Cholesterol (mmol/l)	3.64±0.70	1.88±0.68*	4.49±0.60##
Aspartate aminotransferase activity (U/l)	88.21±14.2	198.42±31.18*	167.2±22.1##
Glucose (mmol/l)	3.71±0.57	3.16±0.74**	3.43±0.73
Calcium (mmol/l)	2.14±0.07	1.92±0.15**	2.11±0.11##
Magnesium (mmol/l)	0.96±0.12	0.83±0.12**	1.01±0.16##
Phosphorus (mg/dl)	5.3±1.6	4.41±1.42*	4.9±1.2
Copper (μg/dl)	118.4±37.2	87.3±11.2**	123.4±22.4##
Potassium (mmol/l)	4.2±0.5	2.4±1.2**	3.6±1.1##
β-hydroxybutyrate (mmol/l)	0.48 ±0.56	3.11±1.32**	1.52±1.22##
Free fatty acids (μmol/l)	441.8±142.1	848.9±123.7**	671.2±92.1##
Leukocytes (1,000/mm^3)	9.1±2.3	16.3±4.2**	12.3±2.6##
Band neutrophils (%)	6±3	12±5**	8±4
Segmented neutrophils (%)	62±7	60±16	61±12
Eosinophils (%)	9±4	8±3	7±5
Lymphocytes (%)	23±12	20±18	24±15
Erythrocytes (million/mm^3)	8.02±2.2	9.3±3.2*	7.8±2.8#
Haematocrit (%)	38.4±11.1	48.2±14.3*	42.1±9.2#
Haemoglobin (g/dl)	9.3±2.1	14.2±3.4**	8.1±2.5##

Values are means ± SEM.

Statistically significant differences of means between control and LDA groups at the baseline (21 days after parturition) were marked using * for P<0.05 and using ** for P<0.001.

Statistically significant differences between 21 and 35 days after parturition in the LDA group were marked using # for P<0.05 and using ## for P<0.001.

Table 2. Percentage number of neutrophils in smear evaluation and uterine diameter in cows from the control and left-sided displacement of the abomasum (LDA) groups determined on 21 (baseline), 35 and 63 days after parturition

Group	Time					
	baseline (21 days after parturition)		two weeks from baseline (35 days after parturition)		six weeks from baseline (63 days after parturition)	
	Neutrophils (%)	Uterine diameter (cm)	Neutrophils (%)	Uterine diameter (cm)	Neutrophils (%)	Uterine diameter (cm)
Control group (n=40)	15.17±2.08	3.5±1.2	8.21±1.72	3.1±1.1	3.12±1.26	3.1±0.9
LDA group (n=40)	41.07±8.52*	6.2±2.3*	32.65±8.72*	5.1±1.8*	13.26±4.03*	3.6±1.3

Values are means ± SEM.

*Statistically significant differences between control and LDA groups at several time points (21 – baseline, 35 and 63 days after parturition) for P<0.001.

Table 3. Reproductive parameters in cows from the control and left-sided displacement of the abomasum (LDA) groups

Group	Reproductive parameters		
	first oestrus after parturition (days from parturition)	services per conception	calving-to-conception interval (days)
Control group (n=40)	40.83±14.15	1.97±1.11	92.22±24.53
LDA group (n=40)	67.09±18.84*	4.54±1.93*	136.87±34.07*

*Statistically significant differences between control and LDA groups for P<0.001.

Discussion

The present study confirmed a significant degree of calcium deficiency in the blood. It presented very low total calcium values of 1.2 mmol/l, which were not only the cause of reduced contractility of the lamina muscularis of the abomasum, but also impaired its secretory functions (Madison and Troutt, 1988). The other investigations also confirmed low calcium values of 1.64 mmol/l during the right-sided displacement of the abomasum, with the same aetiology as that of LDA (Sahinduran and Albay, 2006). On the other hand, no decrease in blood calcium level was found to accompany LDA (De Cardoso et al., 2008). In the present study, the tests conducted prior to surgery, after the diagnosis of LDA, revealed a very low level of potassium, in marked contrast to the results obtained previously – 5.33 mmol/l, and 3.9 mmol/l, but similar to the results showing hypokalaemia – 2.81 mmol/l (Zadnik, 2003; Sahinduran and Albay, 2006; De Cardoso et al., 2008). The low calcium level observed in the present study, like that of the other elements (magnesium, potassium, phosphorus) is caused by reduced absorption from the rumen and reticulum and from the intestines, due to both impaired passage of ingesta and appetite loss resulting from the displaced abomasum. Apart from calcium, only potassium shows such a marked decrease during LDA, and thus the authors believe that reducing potassium when LDA is suspected is significant in the diagnosis of this disease despite the fact that its role in muscle contraction is small. In previous studies, reduced glucose levels in the blood during LDA have been observed; this may impair muscle contractility, including motility of the digestive tract (Holtenius et al., 1998, 2000; Van Winden and Kupier, 2003).

Negative energy balance in cows with a displaced abomasum was described, which results in the formation of ketone bodies and non-esterified fatty acids (Geishauser et al., 1997; Herdt, 2000; Van Winden and Kupier, 2003; Zadnik, 2003; Qu et al., 2013). These authors report that the negative energy balance is induced by disturbances in carbohydrate metabolism in the organism of the cow, as well as increased insulin levels and reduced blood glucose levels. In the present study, the glucose level observed in the experimental group of cows was within physiological range, which may suggest normal energy metabolism, but the blood examination, particularly in the first examination after the LDA diagnosis, showed that the average value for this parameter was considerably lower than in the control group. Moreover,

an increase was noted in FFA and ketone bodies in the form of BHB, which indicates low energy balance in the organism. This may have been due to the fact that the blood evaluation was performed after the onset of abomasal displacement. As shown previously, reduced glucose level is characteristic for cows prior to the onset of LDA, and the glucose level may even increase later (Van Winden and Kupier, 2003; Van Winden et al., 2003). A normal blood glucose level observed in the present study, despite negative energy balance, was maintained because the herd owners used commonly available additives which raise the blood concentration of glucose, such as sodium propionate or propylene glycol. These are used as feed supplements and can be even administered intraruminally, particularly in cases of poor appetite (Holtenius et al., 1998, 2000; Peralta et al., 2011; McArt et al., 2012). Some authors believe that a high blood glucose level may also disrupt the secretory activity of the digestive tract. Reduced abomasum activity during artificially induced hyperglycaemia was found, but it is unclear whether this was due to the elevated glucose level or that of insulin, which was also considerably increased (Holtenius et al., 2000). For this reason, additives that increase blood glucose level should not be used.

The increased level of ketone bodies in the present study occurred as a secondary effect of LDA, which caused reduced feed uptake by the cows. Other authors have similarly noted elevated levels of BHB following LDA diagnosis (Van Winden and Kupier, 2003; Van Winden et al., 2003; De Cardoso et al., 2008; Qu et al., 2013). It was suggested that an elevated BHB level during the antepartum period may indicate energy metabolism disorders in cows after the onset of lactation and the associated disturbances, including increased risk of ketosis and LDA. The increased neutrophil count in this study may be associated with the development of inflammation of the uterus. Other authors, however, have not observed such pronounced leukocytosis, which is mainly associated with the duration and severity of pathological changes (Zadnik, 2003; Sahinduran and Albay, 2006; De Cardoso et al., 2008). Increased Ht levels probably resulted from reduced thirst, but also from the periodic diarrhoea observed in most of the cows with LDA. Our clinical observations confirm nearly 100% occurrence of reproductive disorders in cows suffering from LDA. The present study clearly indicates that LDA occurring in dairy cows after parturition is closely associated with deterioration of reproductive parameters in the herd. The number of services per conception increases over twofold in comparison with the controls, and with the unsuccessful services the calving-to-conception interval, also taken into account in the study, is prolonged. Deterioration of reproductive parameters is very costly for herd owners, involving expenses associated with the number of insemination procedures and the additional time before the next pregnancy, and thus the next calving, which results in increasingly poor milk yield over the course of lactation (Lee and Kim, 2007; Potter et al., 2010; Galvão, 2012).

Finally, the greatest losses result from eliminating cows from the herd because they did not become pregnant (Van Winden and Kupier, 2003; Van Winden et al., 2003; Kasimanickam et al., 2004). Fertility disorders in cows with abomasal displacement may have a number of causes (Van Winden and Kupier, 2003; Melendez et al., 2004; Čengić et al., 2012; Leutert et al., 2013). The most important of these were also observed by the authors of the present study – impaired uterine involution

accompanying LDA, linked to the disturbances in mineral and carbohydrate metabolism described above, which lead to reduced myometrial contractility. Impaired uterine involution was confirmed in the present study; ultrasound examinations showed that the diameter of the uterus was markedly larger in cows with LDA than in cows from the control group. This indicates that the uterus takes longer to be cleaned out after parturition and to return to its normal state, delaying the possibility of pregnancy. Reduced motility of the myometrium and delayed cleaning out leads to the appearance or persistence of endometritis (Melendez et al., 2004; Čengić et al., 2012; Leutert et al., 2013). Poor self-cleaning of the uterus together with impairment of local resistance mechanisms (aggravated in the postpartum period) facilitate microbial proliferation and are the main cause of endometritis (Földi et al., 2006; Sheldon et al., 2009 a; Gautam et al., 2010; Turner et al., 2012).

A persistent inflammatory state is the main problem in later fertility disorders in cows with LDA. Endometritis leads to impairment of endometrial functions, which inhibits conception and implantation and can even result in early abortion. It also leads to disturbances in the ovarian cycle involving the formation of ovarian cysts, prolongation of the luteal phase and delay of the first visible oestrus after parturition, and in consequence, of the return to cyclic ovarian activity, and thus poor reproductive parameters (Sheldon et al., 2002, 2007, 2009 b). Similar disturbances were observed during the present study, in particular a delayed first oestrus after parturition, lack of or delayed ovulation. The cytological examinations confirm the occurrence of endometritis in the cows, both during LDA and after the treatment was completed. Moreover, based on the investigations performed in the present study, it was documented that untreated postpartum inflammation later progresses into subclinical endometritis and can persist for a very long time, even later than 60 days after parturition, resulting in reduced fertility (Gustafson and Emanuelson, 2002; Földi et al., 2006; LeBlanc, 2008; Gautam et al., 2010; Barański et al., 2013). Subclinical inflammatory states do not present external symptoms, which means that they are often not detected by herd owners or even by herd veterinarians. A standard clinical examination of the reproductive system, even with ultrasonography, does not enable diagnosis of subclinical endometritis. These inflammatory states can only be diagnosed by means of cytological, bacteriological or histopathological examination (Barlund et al., 2008; Chapwanya et al., 2010; Dubuc et al., 2010). Unfortunately, these diagnostic methods are not yet standard practice in the management of reproduction in cows.

The authors of the study also aim to draw the attention of veterinarians treating dairy cows to disturbances arising during abomasal displacement, and in particular to the possibility of the illness being accompanied by fertility disorders. It is suggested that veterinary procedure, apart from appropriate treatment of the abomasum, should also include simultaneous evaluation of the reproductive system. On the tenth day after completion of LDA treatment, when it is known to have been successful, a thorough examination of the reproductive system should be carried out, including a cytological evaluation of the uterus, in order to determine any disturbances in the reproductive system or the endometrium, so that uterine inflammation can be diagnosed and treatment started as quickly as possible. In connection with the determina-

tions made in the study, treatment should be based on improving uterine contractility, which will ensure proper involution and self-cleaning, and on prevention or treatment of inflammatory states in the endometrium using appropriate intrauterine medicine. After treatment of the uterus the reproductive examination should be repeated and, depending on the result, treatment should be continued or terminated. The procedure suggested should be applied irrespective of when the abomasal displacement appears, because it is always associated with the risk of concurrent disorders in the reproductive system.

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