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Retrospective evaluation of milk production and culling risk following either surgical, toggle-pin suture or conservative treatment of left displaced abomasum in Chilean dairy cows

P Melendez*[§], C Romero[†], P Pithua*, MP Marin[†], P Pinedo[‡] and M Duchens[#]

Abstract

AIMS: To describe milk yield and culling risk in cows diagnosed with left displacement of abomasum (LDA) treated either conservatively, by right flank pyloric omentopexy, or rolling and toggling, compared with normal herdmates from four Chilean dairy herds.

METHODS: Historical records were obtained from four commercial dairy farms located in Central Chile for cows with a history of LDA between 2010 and 2012, and healthy herdmates. Cows with LDA were categorised into three groups: cows treated with right omentopexy (ST, n=58), cows treated by toggle suturing (TT, n=15) and cows treated conservatively (CT, n=56). Control cows (n=129) were selected from unaffected cows, matched by days in milk (DIM), parity and herd with affected cows. Groups were compared for risk of culling up to 300 DIM and for milk production up to 5 months of lactation using survival and Cox proportional hazard models and mixed models for repeated measures, respectively.

RESULTS: Compared with cows in the Control group, the risk of being culled up to 300 DIM was 9.1 (SE 0.62) times greater in ST cows, 10.4 (SE 0.68) times greater in TT cows, and 37.3 (SE 0.61) times greater in CT cows ($p < 0.01$). In the first 5 months of lactation, compared with cows in the Control group, mean daily milk production was 23.3 (SE 1.5) kg less in ST cows, 15.3 (SE 1.6) kg less in TT cows, and 30.1 (SE 1.3) kg less in CT cows ($p < 0.001$).

CONCLUSIONS AND CLINICAL RELEVANCE: Cows in four dairy herds in central Chile diagnosed and treated for LDA produced significantly less milk and had a higher risk of culling than healthy herdmates. Although cows treated surgically or with toggle suture never recovered to the extent of healthy cows, they produced more milk than cows treated conservatively. However, the retrospective nature of the data,

the inclusion of only four herds and the non-random allocation to treatments means that these conclusions cannot be extrapolated to the overall dairy cattle population in Chile.

KEY WORDS: *Left displacement of abomasum, milk yield, culling, dairy cows, survival*

Introduction

Left displacement of the abomasum (LDA) is a serious digestive disorder that generally affects lactating dairy cattle within the first 30 days in milk (DIM), with a varying incidence (Kelton *et al.* 1998; Goff 2006; LeBlanc *et al.* 2006). This disorder causes tremendous economic losses to the dairy industry mostly due to marked reduction in milk yield among affected cows, substantial treatment costs, and increased culling risks. The estimated cost of LDA has been reported to be US \$432.48 for primiparous and US \$639.51 for multiparous affected cow (Liang *et al.* 2017). In addition, LDA has been linked with increased risk for culling between 1–30 DIM (Gröhn *et al.* 1998).

The cause of LDA is multifactorial. Factors related to LDA are other concomitant periparturient diseases, high body condition score (BCS) at calving, winter season, genotype for milk production, precalving rations, feed bunk management, and high concentrations of non-esterified fatty acid (NEFA) in serum during the prepartum period (Correa *et al.* 1993; Cameron *et al.* 1998). Typical clinical signs in cows include a sudden drop in appetite and reduced milk production, signs of depression, and high concentrations of ketone bodies and NEFA in blood, which can be used as metabolic predictors of LDA in lactating dairy cows (LeBlanc *et al.* 2005).

Treatment for LDA includes either a conservative approach or surgical correction. The conservative treatment involves casting the affected cow on her right side, followed by rolling through a 180 degree arc. However, the effectiveness of this approach is dependent on how quickly a diagnosis is made and many LDA cases treated conservatively tend to relapse (Niehaus 2008). Thus, the conservative approach to LDA treatment is sometimes combined with closed (percutaneous) surgical techniques using a toggle inserted through the skin, while the cow is recumbent after

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BCS	Body condition score
DIM	Days in milk
LDA	Left displacement of the abomasum
NEFA	Non-esterified fatty acids

rolling, to reduce the relapsing risks associated with the conservative technique alone (Niehaus 2008; Sterner *et al.* 2008). Open surgical techniques such as right flank omentopexy, right paramedian abomasopexy, left paralumbar abomasopexy, combined left flank and right paramedian laparoscopy (two-step procedure), or left flank laparoscopy (one-step procedure) can be performed to correct LDA. Surgery is advantageous because it allows manipulation of the abomasum into the correct anatomical position, reducing the risk of relapse and permitting the physical assessment of the pathological state of the abomasum (Niehaus 2008).

Rapid detection and treatment are essential for minimising milk losses and culling risks associated with LDA (Niehaus 2008). However in Chile there is a shortage of veterinarians available to perform corrective surgery on cows affected by LDA. Thus, many cases of LDA that affect cattle in the burgeoning Chilean commercial dairy industry are diagnosed and treated conservatively by farm personnel (P Melendez, unpublished data).

We hypothesised that cows with LDA treated conservatively produced less milk and were culled sooner than LDA-affected cows that were treated surgically. Therefore, the objective of this study was to describe milk yield and culling risk in cows diagnosed with LDA treated either conservatively, by right flank pyloric omentopexy or by rolling and toggling, compared with normal herdmates from four Chilean dairy herds.

Material and methods

Herd selection and management

Data for this study originated from four commercial dairy farms located in Central Chile, an area characterised by a temperate climate. The average temperatures in this region range between 0°C in winter and 30°C in summer while precipitations on record ranged between 150–400 mm per year (Anonymous 2016).

The four high-producing client-owned dairy herds were selected for inclusion in this study based on their ability to electronically capture daily milk yield data, the primary diets for cows were based on feeding a total mixed ration, confinement housing for cows, and willingness to participate in the study. The mean herd size was 683 (SD 28) cows and the rolling herd milk yield 12,530 (SD 538) kg per annum, for the selected herds. Cows were milked three times daily and breeding programmes were based on synchronised artificial insemination. In addition, the selected farms had an early postpartum herd-health monitoring system that permitted surveillance for signs of metritis, ketosis, LDA, and other metabolic disorders affecting the cows, although consistent records for these conditions were not collected. Postpartum cows were monitored daily, up to 13 DIM, for fever, rumen activity, uterine discharges, mastitis, and milk yield. Postpartum monitoring activities were done primarily by farm personnel trained by the consulting veterinarian.

Surgical correction for LDA in the study herds was performed by one of the authors (PM) when his scheduling and availability permitted. Consequently, many cows diagnosed with LDA in this study were treated conservatively by farm personnel. Conservative treatment involved casting the cow on her right side and rolling through a 180 degree arc onto her left side. This was followed

by supportive therapy to correct for fluid and electrolyte anomalies using free-choice access to water and salt blocks. Electrolyte water (60 g NaCl and 30 g KCl in 19 L of water) was provided through a gastric tube in cases of LDA of prolonged duration. For cows exhibiting significant dehydration and metabolic anomalies, I/V therapy with 5 mL/kg hypertonic saline (7.2% NaCl) was given over 5 minutes. Farm personnel monitored treated cows daily for signs of relapse.

Experimental design

Historical records were obtained from computerised record systems (Dairy Comp 305, Valley Agricultural Software, Tulare, CA, USA; Afimilk Ltd, Kibbutz Afikim, Israel) in the selected farms, between 2010 and 2012. Data consisting of cow identification, parity, BCS at dry-off and at calving, calving date, date of LDA diagnosis, daily milk yield (kg) and culling data, for cows with a history of LDA and healthy herd-mates were extracted from the computerised record systems on the study farms.

Left displacement of the abomasum was defined based on prevailing signs including a sudden decline in milk yield, decreased rumen motility, a loss of appetite and animals being off-feed, and metallic sounds between the ninth and twelfth intercostal space on auscultation (Geishauser *et al.* 1998).

The affected cows were categorised into three treatment groups; the first group consisted of cows treated surgically using right omentopexy (ST group, n=58), the second comprised cows treated by toggle suturing (TT group, n=15) and the third included cows treated conservatively (CT group, n=56). Cows with no history of treatment for LDA or other major clinical problem were selected for inclusion as negative controls (Control group; n=129). Controls were randomly selected for each case in a ratio 1:1, matched by DIM (± 5 days relative to the diagnosis of a case), parity, and herd. The Control cows did not have any disease during the first 30 DIM. The outcomes of interest were culling for any reason up to 300 DIM, daily milk yield for each month up to 5 months of lactation, and daily milk yield for each week up to 4 weeks of lactation.

Statistical analysis

Data were analysed using the statistical software Stata 13 (Stata-Corp, College Station, TX, USA). Differences between treatment groups in the distribution of the continuous variables, days to LDA diagnosis and total milk yield up to 300 DIM, were tested using ANOVA, or Kruskal–Wallis tests when the normality assumption for the distribution of a variable was violated (e.g. BCS at calving). For the variables parity (1 or ≥ 2), proportion of cows culled up to 300 DIM and proportion of cows enrolled per herd, differences between groups were tested using the χ^2 statistic.

The time from the onset of lactation to the time when a cow was culled for any reason or until the remaining cows were censored was examined using Kaplan–Meier product-limit plots for each treatment group. Differences in the survival distributions between groups were evaluated using the log-rank test. The relationship between treatment group and the hazard of culling was evaluated by fitting a Cox regression model. Treatment group, parity and herd were included in the model as independent covariates. Within-herd dependence of the hazard of culling distributions was corrected by specifying robust standard errors in the models (Lin and Wei 1989).

Mean daily milk yield for each month for the first 5 months of lactation, and mean daily milk yield for each week for the first 4 weeks of lactation, were compared between treatment groups using a mixed-model ANOVA for repeated measures, with the corresponding covariance structure (Littell *et al.* 1998). As well as treatment group the model included parity (primiparous or multiparous), month (or week) of lactation, herd, and the interaction of group by month (or week) of lactation. Cow was considered as a random effect nested within group. The best fitting model was chosen based on the model with the smallest value of Bayesian information criterion. Least squares means were compared using Tukey's multiple comparison test.

Results

The distribution of cows and summary statistics for the treatment and control groups are presented in Table 1. Median BCS at dry-off and at calving did not differ between the four groups ($p=0.85$), and mean days to diagnosis of LDA did not differ between the CT, ST, and TT treatment groups ($p=0.53$). The proportion of cows that were primiparous was higher in the ST group compared with other groups ($p=0.03$) and the proportion of cows enrolled per herd differed between treatment groups ($p=0.03$). Mean total milk yield up to 300 DIM was higher in the Control group than in the groups treated for LDA ($p=0.001$).

Risk of culling

The proportion of cows culled up to 300 DIM in the Control group was less than in the groups treated for LDA ($p=0.001$; Table 1). Kaplan-Meier plots showed differences in time to culling between treatment groups (Figure 1). The median interval from calving to culling was 28, 195, and 198 days, for the CT, ST and TT groups, respectively. The Cox regression model showed that the risk of culling, corrected for parity and herd, was 37.3 times greater for cows in the CT group than Control cows, was 9.1 times greater for ST than Control cows, and 10.4 times greater for TT than Control cows (Table 2). The risk of culling was higher for CT compared with ST and TT cows ($p=0.03$), but did not differ between TT and ST cows ($p=0.78$).

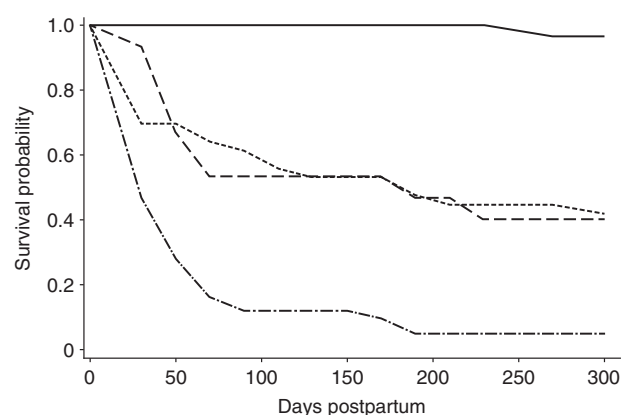


Figure 1. Kaplan-Meier product-limit plots for the interval between calving and culling of cows treated for left displacement of the abomasum (LDA) using omentopexy (· · ·), toggle suture (- · -) or conservative treatment (- - -), or healthy cows with no LDA (—), within four Chilean dairy herds.

Milk production

The change in mean daily milk yield for each month for cows in the four groups for the first 5 months of lactation is shown in Figure 2. There was an interaction between treatment group and month of lactation ($p<0.001$), indicating that the curves for milk production were not parallel between groups. Compared with cows in the Control group, mean daily milk production was 23.3 (SE 1.5) kg less in cows from ST group ($p<0.001$), 15.3 (SE 1.6) kg less in cows from TT group, and 30.1 (SE 1.3) kg less in cows from CT group ($p<0.001$).

The change in mean daily milk yield for each week for cows in the four groups for the first 4 weeks of lactation is shown in Figure 3. There was an interaction between group and week of lactation ($p<0.001$). At 7 DIM, compared with cows in the Control group, mean daily milk production was 13.3 (1.7) kg less in cows from ST group, 11.4 (1.3) kg less in cows from TT group, and 13.6 (1.4) kg less in cows from CT group ($p<0.001$). Between 7 and 28 DIM, mean daily milk production was 5.4 (1.5) kg less in cows from the CT compared with cows from the ST group, and was 4.6 (1.7) kg less than cows from the TT group ($p=0.04$).

Table 1. Number of cows treated for left displacement of the abomasum (LDA) using omentopexy (ST), toggle suture (TT) or conservative treatment (CT), or healthy cows with no LDA (Control), within four Chilean dairy herds, with descriptive statistics for variables in each treatment group.

Variable	Treatment group			
	Control	ST	TT	CT
Number of cows	129	58	15	56
Number of cows per herd (%)				
Herd 1	12 (9)	5 (9)	0 (0)	7 (13)
Herd 2	72 (56)	26 (45)	2 (13)	44 (79)
Herd 3	21 (16)	12 (21)	7 (47)	2 (4)
Herd 4	24 (19)	15 (26)	6 (40)	3 (5)
Number of cows parity 1 (%)	53 (41)	31 (53)	5 (33)	17 (30)
Median BCS at dry-off (min, max)	3.25 (3.0, 3.25)	3.25 (2.75, 3.5)	3.25 (3.0, 3.25)	3.25 (2.75, 3.25)
Median BCS at calving (min, max)	3.5 (3.25, 3.75)	3.25 (3.0, 3.75)	3.5 (3.25, 3.75)	3.25 (3.0, 3.5)
Mean days to LDA diagnosis \pm SE	NA	10.3 \pm 6.1	12.0 \pm 7.0	15.6 \pm 6.9
Number of cows culled up to 300 DIM (%)	3 (2.3)	24 (41)	10 (67)	42 (75)
Mean total milk yield (kg) at 300 DIM \pm SE	13,080 \pm 237	8,310 \pm 389	8,358 \pm 944	6,225 \pm 479

Table 2. Results of Cox regression model comparing the hazard of culling up to 300 days in milk between cows treated for left displacement of the abomasum (LDA) using omentopexy (ST), toggle suture (TT) or conservative treatment (CT), or healthy cows with no LDA (Control), within four Chilean dairy herds.

Variable	HR	SE	P-value ^a
Treatment group			
TT	10.4	0.68	0.006
CT	37.3	0.61	<0.001
ST	9.1	0.62	<0.001
Control	Ref		
Parity			
Primiparous	1.27	0.27	0.39
Multiparous	Ref		
Herd			
1	0.71	0.67	0.61
2	0.51	0.35	0.06
3	0.29	0.43	0.005
4	Ref		

^a Significance of difference compared with reference category (Ref). HR=hazard ratio.

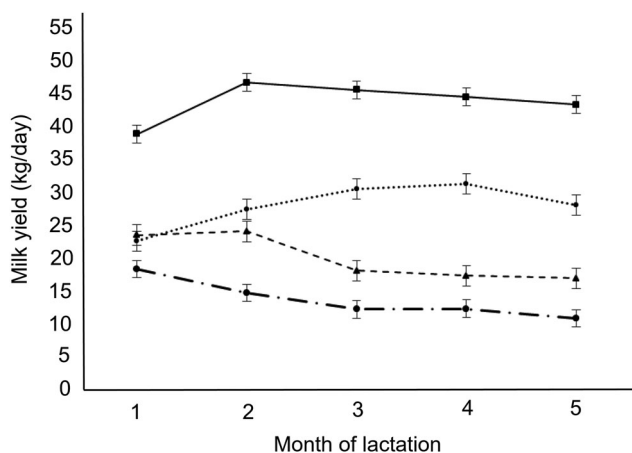


Figure 2. Mean (\pm SEM) daily milk yield per month (kg/day), for the first 5 months of lactation, of cows treated for left displacement of the abomasum (LDA) using omentopexy ($\cdot \cdot \cdot$), toggle suture ($- -$) or conservative treatment ($- \cdot -$), or healthy cows with no LDA ($-$), within four Chilean dairy herds.

Discussion

This is the first study addressing the association between treatment for LDA and milk production and culling risk of dairy cattle raised under contemporary dairy production systems in central Chile. Because of a shortage of veterinarians with experience of LDA surgery, many cows afflicted with this condition are treated conservatively by herd personnel. A strength of this study lay in its ability to permit the use of both negative (i.e. healthy cows with no history of LDA) and positive controls (i.e. cows with LDA treated conservatively) in assessing the relationship between LDA treatment and milk production and culling risks. However, as in previous studies that have evaluated similar questions (Kelton *et al.* 1988; Rohn *et al.* 2004), a drawback of our study included the inability to determine cause and

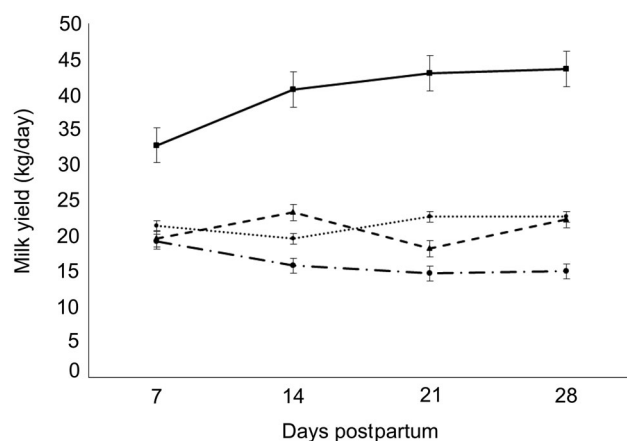


Figure 3. Mean (\pm SEM) daily milk yield per week (kg/day), for the first 4 weeks of lactation, of cows treated for left displacement of the abomasum (LDA) using omentopexy ($\cdot \cdot \cdot$), toggle suture ($- -$) or conservative treatment ($- \cdot -$), or healthy cows with no LDA ($-$), within four Chilean dairy herds.

effect inferences between LDA interventions and the outcomes studied, given the retrospective nature of the data analysed. Although farm personnel were capable of performing both the conservative and toggle procedures, it was impossible to ascertain the underlying reasons informing the decision regarding how a cow with LDA was treated, either conservatively or by toggle suturing, as such information was not available in the database used in the current study. Presumably, the decision may have been based on factors such as the perceived value of the cow, her reproductive or concurrent health status, or some other undefined factors.

In the analysis of risk of culling, the risk was greater for cows in the CT, ST and TT groups than for Control cows. This result concurs with the findings of a study analysing culling following laparoscopic correction of LDA in the Netherlands (Jorritsma *et al.* 2008), when cows with LDA were 1.8 times more likely to be culled in the lactation during which they underwent surgery compared to controls. In contrast, a study from the United Kingdom found that the risk of culling did not significantly differ between cows with LDA that underwent surgical treatment (either parlumbar fossa pyloropexy or paramedian abomasopexy) and controls without a history of LDA, even though the risk of culling was higher in the surgically treated than control cows during the first 2.5 months following surgery (Pedersen 2006). Similar observations were made in a study carried out in California which found a dramatic increase in the risk of culling soon after LDA was diagnosed and following toggle suture correction (Raizman *et al.* 2002).

The results revealed that cows from the CT group were more likely to be culled in comparison to those from ST and TT groups, but the risk of culling was similar between the TT and ST groups. This is in agreement with findings in an earlier trial comparing the effect of toggle pin and open surgical abomasopexy for the treatment of LDA that found no significant difference in culling risks between these two groups (Kelton *et al.* 1988). Factors such as concurrent mastitis status, history of previous LDA, high preoperative risks, and correction of LDA by the herd personnel rather than by an experienced veterinarian have been linked with the increased risk of culling of cows treated for LDA (Sterner *et al.* 2008). In the current study, herd personnel performed toggle suture correction of LDA. Other risk factors that may have influenced the association between LDA treatment and culling risks, such as mastitis, ketosis, milk

fever, endometritis, and history of previous LDA, were not tested because of lack of data regarding these variables.

Overall, cows treated for LDA consistently produced less milk than Control cows. This result is in agreement with findings reported elsewhere. For example, in a study of 12,572 Holstein cows in the United States of America, cows with LDA yielded on average 557 kg less milk than cows without LDA between calving and 60 days of diagnosis (Detilleux *et al.* 1997). Thirty percent of losses in that study occurred before diagnosis. This finding is similar to the current study in which cows diagnosed with LDA between 10–15 DIM were producing about 13 kg less milk at 7 DIM compared with Control cows.

The finding that cows from ST, TT or CT groups produced less milk than Control cows is consistent with a study from California, where cows with LDA that were treated by toggle suture produced less milk than controls, although this difference was only apparent during the first 4 months of lactation (Raizman *et al.* 2002). However, two independent analyses of milk production following surgery for LDA in the United Kingdom and the Netherlands concluded that surgically treated cows did not differ from controls with respect to their 305-day milk production (Pedersen 2006; Jorritsma *et al.* 2008). These contradictory findings may have been a consequence of differences in general dairy production systems, surgical techniques and experiences of the veterinarians performing LDA surgery or other factors (Sterner *et al.* 2008).

The mean daily milk production in cows from the CT group was lower than that of cows from TT and ST group during the first 4 weeks of lactation. This finding is interesting, because there is no other research evidence comparing cows with surgical intervention and cows treated conservatively. This is consistent with results from an earlier study that found no difference in milk production between cows with LDA that underwent correction by toggle suture versus surgical abomasopexy (Kelton *et al.* 1988); however, in that particular study there was no positive control group (conservatively treatment). This suggests that surgical correction of LDA (either toggle or other surgical approach) may have a beneficial effect in terms of milk production compared with conservative treatment.

In conclusion, in this study we demonstrated that cows in four dairy herds in central Chile diagnosed and treated for LDA produced significantly less milk and had a higher risk of culling than healthy herd mates. Although cows treated surgically or with toggle suture never recovered to the extent of healthy cows, they produced more milk than cows treated conservatively. It should be noted that the retrospective nature of the data, the inclusion of only four herds and the non-random allocation to treatments means that we cannot extrapolate the conclusions to the overall dairy cattle population in Chile.

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