Effect of prepartum dry cow antibiotic treatment in dairy heifers on udder health and milk production

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ABSTRACT

A high percentage of heifers calve with intramammary infections. One of the measures available to control intramammary infections is treatment with antibiotics before calving. In this study, the effects of prepartum treatment of nonlactating heifers with a 600-mg cloxacillin dry cow treatment on the prevalence of culture-positive milk samples at calving and 10 to 14 d in milk (DIM), the incidence of clinical mastitis, somatic cell count (SCC), and milk production during first lactation were quantified. A total of 184 heifers on 13 dairy farms were treated with antibiotics 8 to 10 wk before the expected calving date. Another 185 heifers served as untreated controls. Coagulase-negative staphylococci were the most frequently isolated group of bacteria in the treatment and control groups at calving (32 and 42%), and at 10 to 14 DIM (15 and 19%), respectively. The prevalence of minor pathogens at calving was lower in the treatment group compared with the control group (34 and 43%, respectively). *Staphylococcus aureus* was the most frequently isolated major pathogen in the treated and control heifers at calving (4 and 5%) and at 10 to 14 DIM (2 and 3%), respectively. The prevalence of major pathogens was lower in the treated heifers at 10 to 14 DIM compared with the control group (4 and 6%, respectively). Cumulative incidence risk of clinical mastitis during the lactation was 9 and 18% in the treatment and control groups, respectively. Treatment with cloxacillin 8 to 10 wk before calving resulted in a lower prevalence of culture-positive milk samples at calving and lower quarter milk SCC in early lactation [$30,000 \pm 4,600$ (standard deviation) cells/mL in treated heifers versus $40,000 \pm 4,600$ cells/mL in control heifers], and was associated with lower average test-day SCC ($55,000 \pm 1,400$ cells/mL in treated heifers versus $71,000 \pm 1,500$ cells/mL in control heifers) and lower incidence of clinical mastitis throughout lactation. The

improved udder health resulted in a higher average test-day milk production in the first lactation (24.5 ± 3.2 kg in treated heifers versus 23.6 ± 3.1 kg in control heifers). Dairy farms with heifer mastitis problems need to analyze their mastitis management. Prepartum treatment of heifers with dry cow antibiotics may be helpful by decreasing the prevalence of mastitis-causing pathogens at calving and at 10 to 14 DIM.

Key words: dry cow treatment, heifer, mastitis, prepartum

INTRODUCTION

Generally, heifers are assumed to have good udder health and their glands and secretions are often not checked until calving (Nickerson, 2009). The prevalence of IMI in heifers at parturition is assumed to be relatively low by farmers, possibly because they think that mastitis-inducing pathogens are transmitted only at milking. However, IMI in primigravid heifers occur frequently (Fox, 2009). Intramammary infections can develop in young stock, and mastitis-causing bacteria were found in mammary secretions of heifers as early as 8 mo of age (Boddie et al., 1987). Almost 60% of heifers have an IMI in at least 1 quarter at calving, most often with CNS (Oliver and Mitchell, 1983; Trinidad et al., 1990a; Fox et al., 1995). As a result of the IMI, heifers often develop subclinical mastitis manifesting itself after calving as a high SCC. Calving with an elevated SCC results in udder health problems (De Vliegher et al., 2004), decreased milk production (De Vliegher et al., 2005a), and an increased culling hazard (De Vliegher et al., 2005b) in the first lactation. Occasionally, heifers infected before calving freshen with 1 or more nonfunctional quarters (Nickerson et al., 1995). Approximately 16% of Dutch heifers develop clinical mastitis (CM) during their first lactation; at least 30% of those cases occur within 14 d postpartum (Barkema et al., 1998). Additionally, introducing infected heifers into the milking herd may lead to the spread of contagious pathogens, which may influence the udder health situation of the whole herd. The cost of heifer mastitis

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in early lactation on a Dutch or Flemish dairy farm varied from €4 to €82 per heifer with an average of €31 (Huijps et al., 2009).

Several field trials have studied the effect of prepartum antibiotic treatment using lactating cow products (Oliver et al., 2004; Middleton et al., 2005; Borm et al., 2006) and dry cow products (Trinidad et al., 1990b; Owens et al., 1994, 2001) to reduce the occurrence of heifer mastitis. Treatment with lactating cow antibiotic formulations was associated with less IMI after calving (Oliver et al., 2004; Middleton et al., 2005; Borm et al., 2006). Treated heifers produced 455 to 531 kg more milk in the first lactation than control heifers (Oliver et al., 2003). However, in a recently conducted trial performed in 9 research herds, in 5 of the 9 herds, untreated control heifers produced more milk during the first 200 DIM than heifers infused once with a lactating cow product containing cephalixin 2 wk before calving (Borm et al., 2006). This was probably caused partially by a low prevalence of major pathogen IMI in these 5 herds. Similar results were found by Middleton et al. (2005). All studies on the efficacy of dry cow antibiotics in heifers before parturition reported a lower prevalence of IMI at calving in treated heifers (Trinidad et al., 1990b; Owens et al., 1994, 2001), but these studies were all carried out on a small number of farms. Additionally, long-term effects such as incidence of clinical mastitis, test-day SCC, and test-day milk production, which are needed to evaluate the true effect of treatment, were not studied or were not reported.

The purpose of this study was to determine the effect of treating heifers prepartum with a commercially available dry cow antibiotic treatment containing cloxacillin on prevalence of culture-positive milk samples at calving, incidence of CM, test-day SCC, and test-day milk production in the first lactation.

MATERIALS AND METHODS

Herds and Heifers

The trial included 392 heifers in 13 commercial dairy herds, located in a radius of 50 km around the GD Animal Health Service (GD) in Deventer, the Netherlands. Herd owners were approached by practitioners for their willingness to participate. All herds had a good animal identification system, milk recording was carried out every 4 wk, and good record keeping of treatments was in place. Herd size ranged from 38 to 118 lactating cows with an average milk production of 8,518 kg/cow per lactation, ranging from 6,908 to 10,474 kg/cow per lactation. The geometric mean bulk milk SCC per herd in the 6-mo period before the study started was 219,000 cells/mL ranging from 122,000 to 359,000 cells/mL.

Treatments were applied by trained personnel of the GD in alternating order per herd for every heifer reaching the 8 to 10 wk before the expected calving date. The first heifer of a herd that entered the trial was randomly assigned to either the treatment or the control group. For the study, 196 heifers were treated with 1 injection of a dry cow antibiotic containing 600 mg of cloxacillin (Orbenin Extra Dry Cow, Pfizer, Capelle aan de IJssel, the Netherlands) in each quarter, while 196 heifers were left untreated. Before infusion, the udder was cleaned with an individual paper towel, and teats were scrubbed with cotton swabs soaked in methylated alcohol. Treatment was made using partial insertion. A limited number of heifers was excluded from the trial because of having teat lesions, being systemically ill at day of treatment (rectal temperature $>39.5^{\circ}\text{C}$, anorexia, or dehydration), or if they had been treated with antibiotics or anti-inflammatory compounds within 30 d before the treatment. At the time of treatment, the weight of all heifers was estimated by measuring its girth using a calibrated tape line.

Data Collection

Milk recording data (cow-level milk production and SCC) of the included heifers were collected with an interval of 4 wk until 275 DIM. The herdsman recorded at calving (d 0) whether or not assistance was given during calving and whether the placenta was still retained 24 h after calving, whereas the udder and the milk were visually checked for signs of CM at calving and at every milking thereafter. Pre-milking udder preparation with a cotton or paper towel was carried out before milk samples were collected. Quarter foremilk samples were collected aseptically at d 0, 10 to 14 d after calving (d 10–14), and when CM was observed by trained personnel of the GD. Teat ends were disinfected with a cotton swab soaked in methylated alcohol, fore-stripped, and after the third stripping, milk was collected. Milk samples were transported on ice to the GD for bacteriological culture and determination of SCC.

Laboratory Analyses

All milk samples were stored at -20°C before quarter SCC and bacteriological analyses were performed. The samples were thawed at room temperature and the d 10 to 14 samples were split; SCC was determined on the d 10 to 14 samples using a Fossomatic cell counter (Foss Electric, Hillerød, Denmark), and bacteriological culturing was carried out according to the National Mastitis Council protocols (Harmon et al., 1990). An inoculum of 0.01 mL was spread on a 6% sheep blood agar plate and on Edward's medium (Biotrading, Mijdrecht, the

Netherlands). All plates were incubated at 37°C and examined after 24 and 48 h. Edward's medium was used for selective growth of streptococci. Morphology, hemolytic properties, CAMP (Christie, Atkins, Munch-Petersen) reaction, and hydrolyzation of esculin were used to group streptococci according to the Lancefield groups B, C, D, and G. *Streptococcus dysgalactiae* and *Streptococcus agalactiae* were identified using Lancefield media (Oxoid, Basingstoke, UK), with *Strep. dysgalactiae* defined as positive for group C and *Strep. agalactiae* as positive for group B. *Streptococcus uberis* was further identified by a negative reaction with Lancefield group D antiserum and a negative reaction in tryptose phosphate broth with 6.5% NaCl. Isolates of staphylococci showing α , α and β , or β hemolysis were presumptively identified as *Staphylococcus aureus*. Coagulase-negative staphylococci were distinguished from *Staph. aureus* using the Slidex Staph Plus (bioMérieux, Marcy l'Etoile, France) agglutination test. *Escherichia coli* found on blood agar plates were confirmed with the BBL Crystal ID system (Becton, Dickinson, and Co., Franklin Lakes, NJ). Identification of *Bacillus* spp. was based on morphology of the colonies on blood agar plates and on the morphology of the cells as large endospore-forming rods after Gram staining. Identification of *Corynebacterium bovis* was based on morphology of the colonies on blood agar plates.

A milk sample was considered culture-positive if ≥ 100 cfu/mL of a major pathogen (i.e., *Staph. aureus*, *Strep. uberis*, *Strep. agalactiae*, *Strep. dysgalactiae* and *E. coli*) or ≥ 500 cfu/mL of a minor pathogen (i.e., CNS and *C. bovis*) was cultured (Barkema et al., 1997). Milk samples that were culture-positive for more than 2 bacterial species were considered contaminated.

Statistical Analyses

Differences in prevalence of culture-negative and positive quarters between the treatment groups at first (d 0) and second sampling (d 10–14), respectively, were evaluated using Mantel-Haenszel chi-squared analysis on contingency tables. Differences in prevalence of culture-negative and positive quarters within the treatment groups between first and second sampling were evaluated using McNemar's test on contingency tables. No errors were detected in any of the analyses with homogeneity over the different herds (Breslow-Day test > 0.05). Differences in CM cases caused by gram-positive and gram-negative pathogens between the treatment groups were also evaluated using Pearson chi-squared analysis or Fisher's exact test on contingency tables (SPSS version 16.0., SPSS Inc., Chicago, IL).

Mantel-Haenszel adjusted relative risks were calculated using the CM incidence data over all pathogens

of 3 intervals (0 to 30 DIM, 0 to 60 DIM, and 0 to 275 DIM). Using the Breslow-Day test, no problems with homogeneity over herds were detected (OpenEpi version 2.2.1, www.OpenEpi.com)

Differences in quarter natural log SCC (LnSCC) between the treatment groups were evaluated with a linear mixed model correcting for clustering of quarters within heifer (SAS version 9.1.3, SAS Institute Inc., Cary, NC).

Mixed models were fit with daily milk yield (kg) and LnSCC (natural logarithmic transformation of SCC) as outcome variables, including herd and heifer as random effects. An AR(1) covariance structure was included to model the repeated measurements within heifers. Different categorical (treatment, calving season, assistance at calving) as well as continuous predictor variables (BW at start of the trial, DIM at milk recording test day, quadratic effect of DIM, milk yield, and LnSCC at milk recording test day) were included in the regression models. An additional herd-level predictor variable (0/1) was calculated to summarize the heifer mastitis status of the herd. If the geometric average test-day SCC measured between 10 and 35 DIM of all control heifers per herd was $> 200,000$ cells/mL, the herd was classified as a heifer mastitis problem herd. Using this definition, 5 herds were categorized as not having heifer mastitis problems. First, univariate associations were tested, and significant ($P \leq 0.15$) predictor variables were included in the multivariable models. The multivariable model was constructed omitting nonsignificant ($P > 0.05$) predictors from the full model starting with the 2-way interactions (SAS version 9.1.3, SAS Institute Inc.).

RESULTS

Heifers

Twenty-three heifers were excluded from the trial. Four heifers were not pregnant; 3 in the treated and 1 in the control group. Two heifers in the treatment group and 3 in the control group were sold shortly before calving for export. No samples were collected at d 0 and d 10 to 14 from 5 heifers in the treated group and from 7 heifers in the control group. One heifer aborted and 1 heifer was treated i.m. for several days for metritis, both from the treated group. Thus, data were analyzed for 184 heifers in the treatment group and 185 heifers in the control group. Distribution of the number of heifers per herd and treatment group is presented in Table 1. Eight of the 13 herds had a heifer mastitis problem.

Bacteriological Culture Results in Early Lactation

Coagulase-negative staphylococci were the most frequently isolated group of bacteria in all heifers, both at

Table 1. Distribution of udder health measures and milk production in the 13 participating herds in dairy heifers treated with prepartum dry cow antibiotics and control heifers

Herd	Heifers included		Average test-day SCC ¹ (× 1,000 cells/mL)		Average test-day milk production ¹ (kg)		Clinical mastitis (n)	
	Treated	Control	Treated	Control	Treated	Control	Treated	Control
1 ²	3	6	69	63	29.0	26.7	2	0
2 ²	7	6	46	52	25.3	24.4	0	2
3	12	11	34	62	24.3	24.0	2	2
4 ²	20	19	76	65	22.9	23.5	3	4
5	20	20	56	79	28.0	28.2	1	1
6	27	23	60	76	23.9	22.5	1	2
7 ²	14	16	58	80	24.2	23.7	0	2
8	5	7	61	60	24.0	20.3	0	1
9 ²	14	15	50	78	23.8	23.5	0	2
10 ²	23	21	83	106	28.3	28.2	6	4
11	15	18	43	53	22.5	21.3	0	6
12 ²	5	5	39	57	20.6	20.1	0	0
13 ²	19	18	58	83	24.1	20.5	2	7

¹Least squares means based on models including herd and herd by treatment interaction as fixed effects (milk yield not corrected for LnSCC at test-day).

²Denotes farms having a heifer mastitis problem, defined as a geometric mean first test-day SCC of control heifers between 10 and 35 DIM > 200,000 cells/mL.

d 0 and d 10 to 14 (Table 2). *Staphylococcus aureus* was the most frequently isolated major pathogen in both treatment and control groups.

At d 0 and d 10 to 14, more quarters were culture-negative in the treated heifers (52.7 and 75.5%) compared with the untreated heifers (41.6 and 68.8%; Table 2). Significantly more quarters were major-pathogen

positive at d 10 to 14 in the control heifers (6.0%) compared with the treated heifers (3.6%), although this was not true at calving (Table 2). Prevalence of minor-pathogen positive quarters was higher at calving in control heifers compared with treated heifers (43.3 vs. 33.9%), but the difference was smaller at the d 10 to 14 sampling.

Table 2. Bacteriological culture results of heifers treated with prepartum dry cow antibiotics at calving (d 0) and 10 to 14 d after calving (d 10 to 14)

Culture	d 0					d 10 to 14				
	Treated		Control		<i>P</i> -value ²	Treated		Control		<i>P</i> -value
	n	% ¹	n	%		n	%	n	%	
Culture-negative	375	52.7	289	41.6	<0.001	551	75.5	491	68.8	0.005
Major pathogens	65	9.1	75	10.8	0.346	26	3.6	43	6.0	0.039
<i>Staphylococcus aureus</i>	28		34			11		20		
<i>Streptococcus uberis</i>	4		4			1		5		
<i>Streptococcus dysgalactiae</i>	8		16			1		5		
Other streptococci	9		10			8		10		
<i>Escherichia coli</i>	16		11			5		3		
Minor pathogens	241	33.9	301	43.3	<0.001	120	16.4	147	20.6	0.051
CNS	228		290			106		133		
<i>Corynebacterium bovis</i>	13		11			14		14		
Other pathogens	30	4.2	30	4.3	0.967	33	4.5	34	4.8	0.931
<i>Bacillus</i> spp.	15		7			13		27		
Other	4		12			5		3		
Contaminated	11		11			15		4		
Total	711		695			730		715		
No samples collected	25		45			6		25		
Grand total	736		740			736		740		

¹Percentage of total.

²Difference between treated and control for overall culture classes (Mantel-Haenszel chi-squared, no problems detected with homogeneity over the different herds).

Table 3. Days in milk and culture results of all clinical mastitis cases in heifers treated with prepartum dry cow antibiotics and control heifers

Culture clinical mastitis	Treated						<i>P</i> -value ¹	Control					
	DIM					Total		DIM					Total
	0	1–10	11–30	31–60	>60			0	1–10	11–30	31–60	>60	
No sample		1			1	2		1			1	2	4
Culture-negative	3		1			4		4	2	1			7
Gram-positive	1	4	3	1	1	10	0.031	18	3	5	4	4	34
<i>Staphylococcus aureus</i>	1	1	1	1	1	5		6	1	2		3	12
CNS		2	2			4		5	1	2	1		9
<i>Streptococcus uberis</i>		1				1			1	1			2
<i>Streptococcus dysgalactiae</i>								5					5
<i>Arcanobacterium pyogenes</i>								2			3	1	6
Gram-negative	3	4		1		8	0.022	2	1	1	1		5
<i>Escherichia coli</i>	3	3		1		7		1		1	1		3
<i>Bacillus</i> spp.		1				1			1				1
<i>Klebsiella</i>								1					1
Total	7	9	4	2	2	24		25	6	7	6	6	50

¹Difference between total number of gram-positive and gram-negative clinical mastitis cases in control and treated group (Pearson chi-squared analysis or Fisher's exact test).

Clinical Mastitis

Most cases of CM were found at calving, particularly in the control heifers (Table 3). The incidence risk of CM was higher throughout lactation in control heifers compared with treated heifers (Table 4); over the entire lactation, the incidence of CM was approximately 2 times higher in untreated control heifers compared with treated heifers (Table 4).

In the treatment group, fewer cases of CM were caused by gram-positive bacteria compared with the control group ($P = 0.031$), while for gram-negative the opposite was true ($P = 0.022$; Table 3).

SCC

Least squares means of quarter LnSCC at d 10 to 14 was 3.4 ± 1.5 (SD) in treated heifers compared with 3.7 ± 1.5 in control heifers ($P = 0.010$), corresponding to an SCC of $30,000 \pm 4,600$ and $40,000 \pm 4,600$ cells/mL. Least squares means of test-day LnSCC during first lactation in the treatment group was 4.0 ± 0.4 and in

the control group 4.3 ± 0.4 , respectively, corresponding to an SCC of $55,000 \pm 1,400$ and $71,000 \pm 1,500$ cells/mL ($P < 0.0001$; Figure 1, Table 5). Distribution of test-day LnSCC per herd and treatment group is shown in Table 1. Assistance at calving using a mechanical calf puller or with ropes or chains was associated with a lower LnSCC (Table 5). Neither the herd-level predictor indicating herds as having a heifer mastitis problem nor the interaction of this variable with the variable treatment was significant.

Milk Production

Least squares means of test-day milk production in treated and control heifers was 24.5 ± 3.2 and 23.6 ± 3.1 kg, respectively ($P = 0.0008$; Figure 2). Test-day milk yield per herd and treatment group is shown in Table 1. When LnSCC was included in the model, the effect of treatment on test-day milk production tended to decrease to 0.6 kg ($P = 0.088$; Table 6). Heifers calving in autumn had the highest milk production. When no assistance was needed at calving, production

Table 4. Incidence risk of first clinical mastitis in different periods after calving in heifers treated with prepartum dry cow antibiotics

Item	0–30 DIM	0–60 DIM	0–275 DIM
Treatment group (%)	8.2 (n = 15)	8.7 (n = 16)	9.3 (n = 17)
Control group (%)	13.7 (n = 25)	15.4 (n = 28)	17.9 (n = 33)
Risk ratio ¹	0.60	0.57	0.52
95% CI ² risk ratio	0.33–1.09	0.32–1.01	0.30–0.90
<i>P</i> -value	0.095	0.052	0.015

¹Mantel-Haenszel adjusted Breslow-Day test for interaction over herds was not significant.

²CI = confidence interval.

was lower than when a mechanical calf puller or ropes or chains were used. Retained placenta was associated with a lowered milk production as well. On the other hand, heavier heifers at 8 to 10 wk before calving produced more milk. Neither the herd-level predictor indicating herds as having a heifer mastitis problem nor the interaction of this variable with the variable treatment was significant.

DISCUSSION

The prevalence of heifer IMI increases considerably during the last trimester of pregnancy (Fox et al., 1995). Although Owens et al. (2001) found no effect of time of treatment of dry cow antibiotics used in heifers, Fox et al. (1995) stated that methods of controlling mastitis in heifers would likely be most effective if administered during the last trimester of pregnancy. When using dry cow antibiotics, it is necessary to treat at least 60 to 45 d before calving to avoid residues in milk. In our study, the heifers were treated 56 to 70 d before calving.

Supporting another study (Borm et al., 2006), CNS was the most frequently isolated group of bacteria followed by *Staph. aureus* in both groups. The proportion of culture-negative and CNS-positive quarters was higher and lower, respectively, at d 0 in the treatment group compared with the control group, supporting significant decreases in IMI after treatment ranging

Table 5. Final repeated measures mixed model for test-day LnSCC in heifers treated with prepartum dry cow antibiotics

Variables	β	SE	P-value
Intercept	5.471	0.158	
DIM	0.000	0.000	0.015
Treatment			<0.0001
Yes	Ref. ¹	—	
No	0.428	0.092	
Assistance at calving			0.0054
None	Ref.	—	
Mechanical device	−0.050	0.083	
Using ropes or chains	−0.344	0.108	
Milk production (kg/d)	−0.054	0.005	<0.0001
DIM × treatment			0.0100
Treated	Ref.	—	
Control	−0.001	0.000	

¹Referent.

from 30 to 76% (Trinidad et al., 1990a; Owens et al., 2001; Borm et al., 2006). Prevalence of major-pathogen positive samples between d 0 and d 10 to 14 decreased more in the treatment group (5.5%) than in the control group (4.8%), which supports other studies (Owens et al., 2001; Oliver et al., 2003). Both duration of treatment and concentration of the antimicrobial agent in the udder affect the result of treatment of IMI (Barkema et al., 2006).

If performed by untrained personnel, intramammary treatment of nonlactating heifers can be a hazardous experience for both farm personnel and heifers. As a

Figure 1. Natural logarithm of test-day SCC (LnSCC) in heifers treated with prepartum dry cow antibiotics and control heifers during 275 DIM. Data are presented as least squares means and 95% confidence interval.

Table 6. Final repeated measures mixed model for test-day milk production in heifers treated with prepartum dry cow antibiotics

Variables	Model without LnSCC ¹			Model with LnSCC		
	β	SE	<i>P</i> -value	β	SE	<i>P</i> -value
Intercept	19.867	1.825		23.073	1.803	
DIM	0.039	0.005	<0.0001	0.038	0.004	<0.0001
DIM $\times$ DIM	−0.000	0.000	<0.0001	−0.000	0.000	<0.0001
Treatment			0.0008			0.0880
Yes	Ref. ²	—		Ref.	—	
No	−1.420	0.421		−0.588	0.344	
BW (kg)	0.009	0.002	0.0003	0.009	0.002	0.0002
Calving season			<0.001			<0.0001
Jan–Mar	−0.550	0.544		−0.730	0.530	
Apr–Jun	−1.610	0.542		−1.530	0.531	
Jul–Sep	−2.569	0.516		−2.607	0.504	
Oct–Dec	Ref.	—		Ref.	—	
Assistance at calving			0.001			0.0021
None	Ref.	—		Ref.	—	
Mechanical device	1.625	0.445		1.441	0.434	
Using ropes or chains	0.435	0.570		0.066	0.562	
Retained placenta			0.011			0.0124
Yes	Ref.	—		Ref.	—	
No	1.431	0.561		1.366	0.544	
LnSCC				−0.775	0.070	<0.0001
DIM $\times$ treatment			0.049			
Treated	Ref.	—				
Control	0.004	0.002				

¹LnSCC = natural logarithm of test-day SCC.²Referent.

result, the treatment may even result in an increased incidence of gram-negative IMI and CM, particularly if a product is used that has no efficacy for gram-nega-

tive bacteria. In our study, all heifers were treated by trained personnel of the GD who disinfected teats and carefully inserted the short canula in the teat canal.

Figure 2. Test-day milk production (kg/d) in heifers treated with prepartum dry cow antibiotics and control heifers during 275 DIM. Data are presented as least squares means and 95% confidence interval.

Nevertheless, the number of CM cases caused by gram-negative bacteria was significantly higher in the treated quarters, while for the gram-positive cases the opposite was true (Table 3). This may be because cloxacillin is efficacious against gram-positive but not against gram-negative bacteria (Bradley and Green, 2001). Despite the latter finding, the lactational incidence risk of CM was significantly lower in the treated group compared with the control group (Table 4). We hypothesize that the low incidence of CM in the treatment group was due to the lower prevalence of major-pathogen positive milk samples in early lactation. To our knowledge, the proportion of CM in the first lactation was not evaluated in other studies as a measure of efficacy of treatment.

Somatic cell count is an important measure in monitoring udder health in dairy farms. Animals without IMI had a geometric average SCC of approximately 100,000 cells/mL (Schukken et al., 2003). In de Haas et al. (2002), the lactation SCC curve of heifers without CM started shortly after calving with an SCC of 370,000 cells/mL, decreased at 50 DIM to 98,000 cells/mL, and increased slowly to 139,000 cells/mL at the end of lactation. Thirty-five percent of 12,994 Belgian heifers had an SCC > 150,000 cells/mL between 5 and 14 DIM (De Vliegher et al., 2001), whereas 22% of 13,706 Dutch heifers had an SCC > 150,000 cells/mL at the first DHI test after calving (unpublished data). In our study, test-day SCC of treated and control heifers was 55,000 and 69,000 cells/mL, respectively. Treatment with a dry cow antimicrobial product before calving had a significant effect on SCC during the first lactation. The effect of treatment on SCC was the result of a decrease in the proportion of major pathogens in early lactation and CM after calving, supporting other studies (Trinidad et al., 1990a; Owens et al., 1994). In Oliver et al. (2003), where heifers were treated 7 to 14 d before parturition with a lactating cow antimicrobial product, SCC was lower during the first lactation. But, in the multi-state study of Borm et al. (2006) no difference in SCC was found after a single treatment with lactating cow antibiotic formulation 10 to 21 d before calving. This difference may be explained by the selection criteria of the farms, but also by the concentration of antimicrobial products.

In our study, milk production in the first lactation was higher in treated heifers, supporting Trinidad et al. (1990a) and Oliver et al. (2003), who used a dry cow and a lactating cow product, respectively. However, in other studies using a lactating cow formulation (Middleton et al., 2005; Borm et al., 2006), no effect on milk production in the first lactation was found. We found that the decrease in SCC (reflecting improved udder

health) was associated with increased milk production. When LnSCC was included in the model, the association between treatment and milk production was no longer significant, indicating that the positive effect of treatment on milk production was probably the effect of a decreased prevalence of subclinical mastitis, as reflected by the significant effect of LnSCC (Table 6).

In our study, more culture-negative quarters and less CM were found in the first lactation of treated heifers compared with the untreated heifers. Also, treatment with 600 mg of cloxacillin effectively decreased SCC and increased milk production in the first lactation. Thus, treatment with dry cow antibiotics before calving may be effective for preventing CM, and in reducing the risk of antimicrobial residues in lactating heifers during the first lactation, while there was no milk loss when heifers are treated before calving. Blanket dry cow therapy in cows is an accepted procedure worldwide in dairy farms. Although a positive effect was found in most herds in this study, adopting blanket treatment with dry cow antibiotics in nonlactating heifers as a routine procedure may not be warranted. The 13 dairy herds in our study were not randomly chosen. Also, 8 out of 13 had a heifer mastitis problem as reflected by the average first-test day SCC of the control heifers. Still, it was not possible to show that treatment only worked well in those herds because the interaction between treatment and the herd-level variable reflecting the heifer mastitis status was not significant. Nevertheless, all herds included were interested in preventing heifer mastitis, based on recent or historical heifer mastitis problems. Prepartum treatment of heifers with dry cow antibiotics may temporarily help in solving heifer mastitis problems, but dairy farms with this problem need to analyze their mastitis management. Additionally, when carried out by insufficiently trained personnel, intramammary treatment of nonlactating heifers is not without risk for the personnel and the heifer.

CONCLUSIONS

Intramammary treatment with a dry cow product containing 600 mg of cloxacillin at 8 to 10 wk before calving on 13 commercial dairy herds resulted in a lower prevalence of culture-positive milk samples containing mastitis-causing bacteria at calving and at 10 to 14 DIM, and prevalence of major-pathogen positive samples was lower in treated heifers at 10 to 14 DIM as well. In early lactation, quarter milk SCC was lower in treated heifers. During the rest of the lactation, average test-day SCC and incidence risk for of CM were lower in treated heifers, which resulted in a higher average test-day milk yield.

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