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Clinical and Economic Effects of an Internal Teat Sealant at Dry-off on the Incidence of Clinical Mastitis in Early Lactation

Paul Baillargeon[1], *DVM, MSc;* **Stephen J. LeBlanc**[2], *BSc(Agr), DVM, DVSc*
[1]*Pfizer Animal Health, 250 Route 236, St-Louis de Gonzague, Quebec JOS IT0;*
[2]*Population Medicine, Ontario Veterinary College, University of Guelph, Ontario, Canada*
Corresponding author: Dr. Baillargeon, 450-371-4783 (phone); 450-371-5299 (fax); paul.baillargeon@pfizer.com

Abstract

Twelve commercial dairies in Quebec, Canada, evaluated the clinical and economic effects of using an internal teat sealant (ITS; Orbeseal®) combined with standard intramammary antibiotic dry-cow treatment on the incidence of clinical mastitis in early lactation. A total of 1,334 Holstein cows were randomly assigned to treatment of all four quarters with an antibiotic dry cow treatment (ADCT) alone or with antibiotic treatment and an internal teat sealant (ADCT+ITS) at dry-off. The incidence rate of clinical mastitis per 100 cow-days at risk during the first 105 days-in-milk was 22% lower (relative risk = 0.78; 95% confidence interval 0.61 to 1.01) for the ADCT+ITS group than for the ADCT group. The daily probability of experiencing clinical mastitis, starting at calving, was reduced by 24% for the ADCT+ITS group. The net benefit, based on lost milk production associated with clinical mastitis, was approximately $20 Canadian (CDN) per cow for the ADCT+ITS group due to the lower incidence of clinical mastitis, particularly soon after calving.

Key words: dairy cow, clinical mastitis, dry-off, teat sealant, dry cow therapy

Résumé

L'impact clinique et économique de l'utilisation de scellant à trayons intramammaire (ITS; Orbeseal®) en combinaison avec un traitement antibiotique intramammaire de routine pour vaches taries sur l'incidence de mammite clinique tôt dans la lactation a été étudié dans douze fermes laitières commerciales du Québec, Canada. On a alloué au hasard 1334 vaches Holstein dans deux groupes de traitement des quatre quartiers, soit le traitement antibiotique pour vaches taries (ADCT) ou soit ce même traitement en combinaison avec le scellant à trayons intramammaire (ADCT+ITS) au tarissement. Le taux d'incidence de mammite clinique par 100 vaches-jours à risque durant les premiers 105 jours en lait était réduit de 22% (risque relatif = 0.78; intervalle de confiance à 95%: 0.61-1.01) dans le groupe ADCT+ITS comparé au groupe ADCT. La probabilité journalière d'être sujette à la mammite clinique, commençant au vêlage, était réduite de 24% dans le groupe ADCT+ITS. Le bénéfice net, basé sur la perte de production laitière associée à la mammite clinique, était approximativement de 20$ Canadien (CDN) par vache dans le groupe ADCT+ITS en raison de la plus faible incidence de mammite clinique, particulièrement peu après le vêlage.

Introduction

The use of antibiotic therapy at the end of lactation is a widespread practice and an effective means of controlling mastitis, with benefits to animal health including improved milk production and quality.[7] The incidence of new intramammary infections (IMI) through the dry period in untreated quarters is 8 to 16%, with the highest risk period during the first three weeks of the dry period and just before calving.[7,19] Consequently, treating all quarters of all cows with a long-acting, dry-cow antibiotic at the time of dry-off is widely recommended in North America.[7] Although a keratin plug typically seals the teat after dry-off, 40 to 50% of teats remain open during the first week, and 23% of teats are still open six weeks later.[7] Teats of high-producing cows may be less likely to form keratin plugs naturally.[7] The antimicrobial spectrum of most commercial intramammary (IMM) antimicrobials for use at dry-off is primarily efficacious against some gram-positive bacteria. The effective concentrations of these products are restricted to the first two to three weeks of the dry period,[14] which reduces their ability to prevent IMI and clinical mastitis (CM) at calving. Therefore, dry-cow treatment provides little protection against infections by gram-negative bacteria and for the latter portion of the dry period. A large proportion of new IMI established in the dry period are associated with bacteria from environmental reservoirs, such as *Escherichia coli* and *Streptococcus uberis*.[4]

An internal teat sealant (ITS) is commercially available. The ITS is an inert, non-antibiotic paste of bismuth subnitrate intended to physically prevent invasion of mastitis-causing organisms throughout the dry period. Persistency for up to 100 days after insertion in the teat cistern has been demonstrated.[21] The first published results regarding ITS use demonstrated equivalent efficacy to a broad-spectrum, long-acting IMM antibiotic (250 mg cephalonium) for preventing new cases of mastitis at calving and throughout the first five months of lactation.[21] In North America, this ITS has been used in conjunction with antimicrobial dry-cow therapy (ADCT) due to the challenge of rapidly distinguishing between infected and uninfected quarters under field conditions,[15] and because the incidence of new IMI at calving remains relatively high despite extensive use of conventional dry-cow therapy. Godden *et al*[8] examined the efficacy of using the ITS in addition to IMM cloxacillin benzathine at dry-off with treatments assigned at the quarter level within cow (n = 419 cows). Quarters treated with the ITS were 30% less likely to develop a new IMI during the dry period, 33% less likely to develop a case of CM between dry-off and 60 days-in-milk (DIM), and 83% less likely to have CM due to environmental streptococci, compared with quarters treated only with antibiotic. Similarly, Newton *et al*[12] used a split-udder design to examine the effect of an ITS in addition to ADCT. They reported a 30% reduction in the prevalence of IMI and a 54% lower incidence of CM to 100 DIM with the combined treatment among 283 cows with somatic cell count (SCC) > 200,000 at dry-off. In a cow-level (assignment of all four quarters to ADCT or ADCT + ITS) field study with 528 cows, Cook *et al*[5] reported a 59% reduction in IMI at one to three DIM, and a 35% relative reduction in the rate of CM (time to the first case) from calving to 60 DIM in cows that received both treatments. Sanford *et al*[16] measured IMI status before dry-off. Among 408 cows with IMI at dry-off, the incidence of new IMI to eight DIM was reduced by 50% in cows that received ADCT + ITS relative to ADCT alone. Among 326 cows classified as having no IMI at dry-off, there was no difference in new IMI through the dry period between ITS alone or ADCT alone.

There are few studies in small to medium size herds under North American conditions with sufficient power to examine the effect of ITS on the incidence of CM, and the economics of the decision to add an ITS to treatment of all quarters of all cows with ADCT. This randomized clinical trial was designed to evaluate the efficacy of an ITS combined with conventional ADCT in reducing the incidence of CM in early lactation, compared with conventional ADCT alone. An additional objective was to evaluate the financial benefit of combined treatment with an ITS and ADCT arising from any reduction in the incidence of CM in early lactation.

Materials and Methods

Herd selection and cow enrollment

The study was conducted on 12 representative commercial dairy farms in Quebec, Canada (Table 1). Herd selection was based on willingness to follow the protocol, availability of computerized herd record software,[a] and cooperation of the attending veterinarians to monitor compliance with the protocol during their routine herd health visits. Producers also had to perform Dairy Herd Improvement (DHI) milk recording, including individual cow SCC monthly, and to authorize access to the DHI data and their DSA records by the principal investigator during the study. Herd size varied between 40 and 400 cows. Target sample size was approximately 1,490 Holstein cows over a period of 12 months, based on detection of a change in the risk of CM in early lactation from 25% to 19% of cows with a first case, with 95% confidence and 80% power.[6] Animals were housed, fed, and managed in accordance with regular management practices on the recruited farms.

Participants and their employees were instructed by the principal investigator regarding the study protocol. At scheduled dry-off, all cows that were being retained for the next lactation were enrolled in the study and randomly assigned to receive either an approved IMM ADCT alone[b or c] (the same product was used on all cows within a herd), or an ADCT plus ITS (bismuth subnitrate (65% w/w)[d] in an oil base paste). All cows were treated in all four quarters. Randomization was based on cow identification numbers: cows with odd numbers received only ADCT and cows with even numbers received the ADCT + ITS. In the ADCT + ITS group, after administration of the ADCT each teat was disinfected again with an alcohol pad before a single tube of the ITS was slowly infused in each teat, according to the manufacturer's recommendation. Treatments were administered by the herdsmen or a trained employee at each site and recorded in the herd diary used on each farm for the capture of all herd events. These data were entered into the DSA computerized herd record by the attending veterinarian during routine herd visits.

Observations and data collection

Cows completing a dry period of 28 to 120 days were included in the data set starting at calving. Cows were monitored at each milking (until 105 DIM for this study) for cases of CM, defined as visibly abnormal milk (e.g., presence of clots, watery secretion) beyond the third fore-stripping, with or without signs of abnormality in the quarter or signs of systemic disease. When CM was

Table 1. Description of herds in a randomized clinical trial of the addition of an internal teat sealant to intramammary antibiotic treatment at dry-off in Holstein dairy cows.

Herd	Herd size (number of milking cows)[1]	Rolling herd average of 305-day milk production		Bulk tank SCC[1]	Housing type	
		lb	kg		Dry cows	Lactating cows
1	78	19,763	8,983	290	Free stall	Tie stall
2	36	18,467	8,393	281	Tie stall	Tie stall
3	404	18,271	8,305	334	Free stall	Free stall
4	124	18,500	8,409	158	Free stall	Free stall
5	79	18,913	8,597	168	Tie stall	Free stall
6	194	19,664	8,938	373	Free stall	Free stall
7	162	21,375	9,716	123	Free stall	Free stall
8	83	19,105	8,684	402	Tie stall	Tie stall
9	45	21,611	9,823	204	Free stall	Tie stall
10	65	19,554	8,888	181	Tie stall	Tie stall
11	95	19,063	8,665	245	Free stall	Free stall
12	68	18,367	8,348	173	Tie stall	Free stall

[1]Geometric mean for the three monthly DHI reports preceding the start of the study.

detected, producers aseptically collected a sample of milk from the affected quarter and recorded the case in the herd diary. Samples were stored at -4°F (-20°C) on the farm until they were picked up by the attending veterinarian and shipped to the clinical bacteriological laboratory of the Faculté de Médecine Vétérinaire (FMV), Université de Montréal in St-Hyacinthe, QC.

Participating herds were enrolled on DHI[e] and submitted a preserved milk sample monthly for the determination of milk constituents and SCC. Production data were transferred electronically into the DSA individual cow file of each herd by the attending veterinarian. The projected estimate of milk production for 305 days was calculated with the DSA software using data from at least the first four months of lactation. Data on culling and pregnancy were retrieved from the DSA software approximately 13 months after the last cow was enrolled on the study.

Milk culture analysis

Bacteriological analysis was performed at the clinical bacteriological laboratory of the FMV according to National Mastitis Council (NMC) guidelines.[10] Samples were thawed overnight in a refrigerator or for 30 minutes in a water bath at 72°F (22°C), and 10µL was inoculated using a disposable loop onto a Columbia agar plate enriched with 5% sheep's blood.[f] If there was no growth after 24 hours, enrichment was performed by incubating the original sample at 95°F (35°C) overnight followed by the inoculation of a Columbia agar plate enriched with 5% sheep's blood using a swab.

After incubation for 24 hours, the plates were examined and colonies tentatively identified on the basis of morphologic features and pattern of hemolysis. Gram staining and catalase testing were performed and the colony forming units (CFU) were enumerated. A second reading was made at 48 hours. Gram-positive, catalase-positive cocci were submitted to coagulase testing or, if necessary, a DNase test to distinguish between *Staphylococcus aureus* and coagulase-negative staphylococci (CNS). Gram-positive, catalase-negative cocci, presumptively identified as streptococci, were submitted to CAMP reaction, esculin hydrolysis, hippurate hydrolysis and inulin and raffinose fermentation, or if necessary for definitive identification, the API20S system.[g] Gram-positive bacilli were classified according to their microscopic morphologic features and the results of the catalase test. Gram-negative bacilli were inoculated onto MacConkey agar[h] and identified with oxidase, triple sugar iron, urea, citrate, indole, and motility tests. Other bacteria or yeast were identified according to morphologic features with gram staining.

Staphylococcus aureus was considered the cause of CM if ≥ 100 CFU/mL were isolated.[10] Isolation of

≥ 200 CFU/mL of environmental mastitis pathogens (*Escherichia coli*, streptococci other than *Streptococcus agalactiae*, *Enterococcus* spp, *Klebsiella* spp, *Arcanobacterium pyogenes*, *Serratia* spp, *Pseudomonas* spp, or *Pasteurella* spp) or ≥ 1,000 CFU/mL of *Corynebacterium bovis*, CNS, yeasts, molds, fungi, or *Bacillus* spp were considered significant. Milk samples containing three or more isolates were considered to be contaminated unless *Staph aureus* or *Strep agalactiae* were isolated.[13]

Statistical analysis

Data including herd, parity, treatment group, dates of calving, CM and culling, milk culture results, and DHI information from the first three test days of lactation were exported from DSA through a spreadsheet for analysis. Statistical analyses were performed using SAS 9.1.3.[i] Univariable analyses of the association of treatment with the risk of CM and with culling during the study period were performed with WinEpiScope 2.0.

The main outcome of interest was the incidence of CM between calving and 105 DIM, which was measured three ways using multivariable regression models, all of which accounted for the correlation of cows within herd by including a random effect of herd. The covariates parity group (lactation 1, 2, 3, or ≥ 4) and season of calving were screened in univariable analyses for association with the measure of CM. The effect of treatment and covariates were then offered to multivariable models using manual backward stepwise elimination. The first measure of CM was the probability of having a case of CM (i.e., yes or no to ≥ 1 case) by 105 DIM, which was modeled using logistic regression (GLIMMIX procedure in SAS with binary distribution and logit link). The second measure was to model the incidence density of CM per 100 cow-days at risk (i.e., the number of cases of CM per number of days at risk of a case, where repeat cases at the cow level, irrespective of pathogen, had to be > 14 days later to be counted as a new case), using Poisson regression (GLIMMIX procedure in SAS with Poisson distribution, log link and offset = log (days at risk of CM/100)). The incidence density of CM was also modeled with a negative binomial distribution, but the estimates of treatment effect were identical to the Poisson model. Finally, the time to the first case of CM was modeled using survival analysis with Cox's proportional hazards regression (the PHREG procedure in SAS, with the PHLEV macro to include a random herd effect). The survival function estimates from the final model were exported to Sigma Plot 10 for graphic display.

Time to pregnancy was modeled using survival analysis, with non-pregnant cows censored on the date of culling or, if still in the herd but not pregnant, as of January 1, 2008 (approximately 13 months after the last cow was enrolled). Univariable median time to pregnancy was calculated with Kaplan-Meier analysis (LIFETEST procedure in SAS) and Cox's proportional hazards regression (the PHREG procedure in SAS) was used for multivariable analysis of pregnancy rate.

Economic analysis

The economic analysis was based on a calculation of production losses associated with CM using a computerized spreadsheet[j] previously employed to estimate the economic benefit of use of the same ITS.[5] Estimation of the marginal costs and benefits of use of the ITS was based on the reduction in milk production after a first episode of CM, taken from a large field study,[20] considering the week of lactation in which the case occurred, and the following assumptions: $1 CDN = $0.95 US; gross revenue for milk = $0.30 US/lb ($0.71 CDN/kg); four days of milk discard for all cows at the start of lactation due to ADCT; all cases of CM were treated with IMM antibiotics with four days of milk discard following antibiotic therapy; and the cost of the ITS was $2.38 US ($2.50 CDN) per tube, or $9.50 US ($10 CDN) per cow. The observed weekly incidence rates of CM for the first 15 weeks of lactation were used to determine the difference in loss of saleable milk for the whole lactation between treatment groups. The spreadsheet did not consider the cost of the IMM antimicrobial to treat each case of CM, the cost of labor, or effects associated with SCC, such as milk price premiums.

Results

Study animals

Table 1 describes the herds in the study. A total of 1,430 cows from 12 herds calved after being enrolled at dry-off between June 2005 and November 2006. Cows were excluded if the length of the dry period was < 28 days (n = 20) or > 120 days (n = 76). A total of 1,334 cows were included in the analysis, distributed between the ADCT group (n = 669) and the ADCT+ITS group (n = 665). The median herd size was 81 lactating cows at start of the trial, and herds contributed between 23 and 276 animals to the study. Five herds were housed in tie-stall barns and seven herds were housed in free-stall barns. All herds kept milking cows inside throughout the year. Table 2 shows there were no differences in average dry period length, parity, and projected 305-day milk production for each experimental group.

Risk of a first case of clinical mastitis in the first 105 days of lactation

A total of 222 cows had at least one case of CM during the first 105 days of lactation. Fewer cows had a case of CM before 105 DIM in the ADCT+ITS group (n = 97/665; 15%) than in the ADCT group (n = 125/669; 19%); relative risk (RR) = 0.78, 95% CI 0.61 to 0.99, $P =$ 0.05. In the ADCT+ITS group 11/97 cows had a second case (> 14 days after the first) of CM before 105 DIM vs 17/125 cows with a second case in the ADCT group (RR = 0.83, 95% CI 0.4 to 1.7; P = 0.69). Accounting for the significant covariates parity and season of calving and the random effect of herd, cows that received ADCT+ITS were 26% less likely to have a case of CM before 105 DIM (odds ratio (OR) = 0.74, 95% CI 0.55 to 0.99; P = 0.05; Table 3). The length of the dry period or the season of dry-off were not associated with the risk of a first CM case. There were no interactions (P > 0.2) of treatment with parity, season of dry-off, or season of calving. The effect of ADCT+ITS was greatest for cows that were dried off or calved in summer, but the direction of the effect (RR = 0.7 to 0.9) was the same in all seasons.

Impact of treatment on incidence rate of clinical mastitis

The unadjusted incidence rates of clinical mastitis (IRCM) for the 105 DIM for the ADCT+TS and the ADCT groups were 0.16 and 0.21 cases per 100 cow-days at risk, respectively. Accounting for parity, season of calving, and the correlation of cows within herd, the incidence density of CM in the first 105 days of lactation was 22% lower in the ADCT+ITS group than in the ADCT group (relative rate = 0.78; 95% CI 0.61 to 1.10, P = 0.06; Table 4).

Table 2. Description of 1,334 Holstein cows in 12 herds enrolled in a randomized clinical trial of the addition of an internal teat sealant to intramammary antibiotic treatment at dry-off.

	Antibiotic dry cow treatment plus internal teat sealant			Antibiotic dry cow treatment			*P*-value t-test
	n	mean	SD	n	mean	SD	
Dry period length (days)	665	62.6	17.9	669	61.0	16.3	0.10
Parity	665	3.29	1.42	669	3.33	1.57	0.61
Projected 305-day milk production	540	20,764 lb (9,438 kg)	3,194 (1,452)	544	20,887 lb (9,494 kg)	3,267 (1,485)	0.53

Table 3. Final logistic regression model of the effect of the addition of an internal teat sealant to intramammary antibiotic treatment at dry-off on the probability of having ≥ 1 case of clinical mastitis before 105 days-in-milk in a randomized clinical trial in 1,334 Holstein cows in 12 herds.

Variable	Level	Estimate	SE	Odds ratio	95% CI	*P*-value
Intercept		-1.890	0.266			
Treatment	Antibiotic dry cow treatment + internal teat sealant	-0.301	0.152	0.74	0.55 - 0.99	0.047
	Antibiotic dry cow treatment	referent	-	-	-	-
Parity	2	-0.669	0.188	0.51	0.35 - 0.74	0.0004
	3	-0.078	0.180	0.93	0.65 - 1.32	0.66
	≥ 4	referent	-	-	-	-
Season of calving	Spring	0.390	0.235	1.48	0.93 - 2.34	0.097
	Summer	0.461	0.217	1.59	1.04 - 2.43	0.034
	Fall	0.311	0.216	1.36	0.89 - 2.08	0.150
	Winter	referent	-	-	-	-

Table 4. Final Poisson regression model of the effect of the addition of an internal teat sealant to intramammary antibiotic treatment at dry-off on the incidence density of clinical mastitis before 105 days-in-milk in a randomized clinical trial in 1334 Holstein cows in 12 herds.

	Level	Estimate	SE	Relative risk per 100 cow-days at risk	95% CI	*P*-value
Intercept		-1.857	0.220	-	-	-
Treatment	Antibiotic dry cow treatment + internal teat sealant	-0.246	0.128	0.78	0.61 - 1.01	0.056
	Antibiotic dry cow treatment	referent	-			-
Parity	2	-0.589	0.161	0.55	0.41 - 0.76	0.0003
	3	-0.078	0.150	0.93	0.69 - 1.24	0.60
	≥ 4	referent	-	-	-	-
Season of calving	Spring	0.223	0.204	1.24	0.84 - 1.86	0.28
	Summer	0.408	0.183	1.50	1.05 - 2.15	0.03
	Fall	0.248	0.184	1.28	0.89 - 1.83	0.18
	Winter	referent	-	-	-	-

Time to first case of clinical mastitis in the first 105 days-in-milk

Figure 1 shows a survival curve of the time to the first case of CM in the first 105 days of lactation. Accounting for parity and season of calving, cows in the ADCT+ITS group had a daily probability of mastitis 24% lower (hazard ratio = 0.76, 95% CI 0.59 to 0.97; P = 0.03) than cows in the ADCT group during that period.

Milk culture results

Eighty percent (78/97) and 79% (99/125) of first CM cases were submitted for bacterial culture in the ADCT+ITS and the ADCT groups, respectively. Samples were not taken by the producers in the remainder of cases. Table 5 shows the distribution of pathogens that were isolated. The unadjusted risk of CM caused by coliform pathogens was lower in the ADCT+ITS group than in the ADCT group (3.0% vs. 5.4%, respectively; RR = 0.71, 95% CI 0.52 to 0.97; P = 0.03). There were no other significant pathogen-specific differences between groups.

Somatic cell count linear score, culling, and reproduction

Although IMI was not measured, the proportion of cows with SCC > 200,000 (a surrogate estimate of IMI) at the last DHI test before dry-off was similar (38% in the ADCT+ITS group and 35% in the ADCT group; P = 0.26). At the first DHI of the subsequent lactation, 22% of cows in the ADCT+ITS group and 27% of cows in the ADCT group had SCC > 200,000 (Chi-square P = 0.03). Table 6 shows the least-square means for SCC linear score at the first three DHI tests for each experimental group.

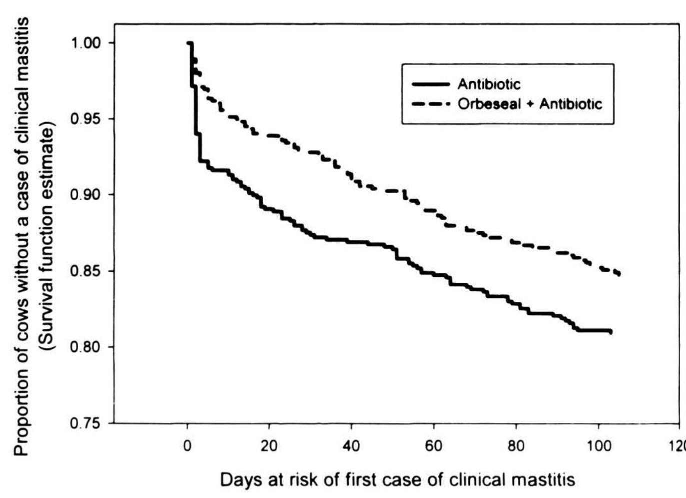

Figure 1. Cox proportional hazards regression of time to the first case of clinical mastitis in the first 105 days of lactation following random assignment to receive an internal teat sealant in addition to intramammary antibiotic treatment at dry-off in 1,334 cows in 12 herds.

Table 5. Bacterial pathogens cultured from first cases of clinical mastitis during the first 105 days of lactation in cows randomly assigned to receive an internal teat sealant in addition to intramammary antibiotic treatment at dry-off.

Result of bacteriology of pre-treatment milk sample	Treatment group			
	Antibiotic dry cow treatment plus internal teat sealant, n=97		Antibiotic dry cow treatment, n=125	
	N	% of cases cultured	n	% of cases cultured
Coliforms[1]	20	26	36	36
Streptococcus uberis	10	13	6	6
Streptococci other than *S. uberis*	8	10	18	18
No growth	14	18	19	19
Staphylococcus aureus	11	14	5	5
Coagulase-negative staphylococci or *Corynebacterium bovis*	5	6	6	6
Other	5	6	6	6
Contaminated[2]	5	6	3	3
Total	78		99	

20% of cases in each group were not sampled for bacteriology.
[1]*E. coli* and *Klebsiella* spp.
[2] ≥ three species of bacteria isolated.

Table 6. Least square mean somatic cell count linear score for first three DHI tests from mixed linear regression models accounting for parity, season of calving, and a random effect of herd in 1,334 cows in 12 herds. Cows were randomly assigned to receive an internal teat sealant in addition to intramammary antibiotic treatment at dry-off.

DHI Test	Treatment group				*P*-value
	Antibiotic dry cow treatment plus internal teat sealant		Antibiotic dry cow treatment		
	Mean linear score	SE	Mean linear score	SE	
First	2.72	0.16	2.90	0.16	0.11
Second	2.27	0.17	2.50	0.17	0.07
Third	2.44	0.18	2.50	0.18	0.62

The cows in the ADCT+ITS group tended ($P \leq 0.11$) to have lower linear scores at the first two DHI test days of lactation than cows receiving only ADCT at dry-off.

There was no difference between treatment groups in the proportion of cows that were sold or died in the first 105 DIM (8.1% in the ADCT+TS group and 8.2% in the ADCT group).

The unadjusted median time to pregnancy was 157 and 170 days in the ADCT+ITS and the ADCT groups, respectively. Accounting for the significant covariate parity, the speed at which cows became pregnant was not significantly different between treatment groups (hazard ratio for the ADCT+ITS group = 1.1, 95 CI 0.97 to 1.25; $P = 0.12$).

Economic analysis

Based on the reduction in the frequency of CM, particularly in very early lactation, approximately 9,460 lb (4,300 kg) more saleable milk (lactational total) per 100 cows was estimated to be available from cows in the ADCT+ITS group (Table 7). With a gross value of $0.30 US/lb ($0.71 CDN/kg) of milk sold, and a cost of ITS of $9.50 US ($10.00 CDN) per cow, the net average benefit of adding the ITS was $19.47 US ($20.49 CDN) per cow.

Discussion

The reduction in the incidence of CM associated with addition of this commercial ITS to ADCT of all quarters of all cows is consistent with the results of similar studies. At the time of initiation of the present study (June 2005), there were few published studies on the effect of OrbeSeal® on the incidence of CM when used under North American field conditions, including

Table 7. Economic analysis of the loss of saleable milk due to clinical mastitis (CM) in early lactation in 1,334 cows in 12 herds with cows randomly assigned to receive an internal teat sealant in addition to intramammary antibiotic treatment at dry-off, using the method of Cook *et al*,[5] based on production losses reported by Wilson *et al*[20] ($1 CDN = $0.95 US).

Week of lactation in which CM occurred	Reduction in milk production for the lactation attributable to a case of CM (lb (kg))	Antibiotic dry cow treatment plus internal teat sealant (ITS)		Antibiotic dry cow treatment	
		Incidence of CM per 100 cows at risk	Milk loss in cows with a case of CM (lb (kg))	Incidence of CM per 100 cows at risk	Milk loss in cows with a case of CM (lb (kg))
1	1,573 (715)	3.93	6,186 (2,812)	8.41	13,231 (6,014)
2	1,663 (756)	1.53	2,548 (1,158)	1.36	2,266 (1,030)
3	1,641 (746)	0.62	1,016 (462)	1.67	2,743 (1,247)
4	1,593 (724)	1.09	1,740 (791)	1.53	2,438 (1,108)
5	1,531 (696)	0.79	1,203 (547)	1.39	2,123 (965)
6	1,472 (669)	2.37	3,487 (1,585)	0.47	684 (311)
7	1,395 (634)	0.32	444 (202)	0.62	871 (396)
8	1,320 (600)	0.96	1,267 (576)	1.88	2,479 (1,127)
9	1,245 (566)	1.60	1,995 (907)	0.63	785 (357)
10	1,175 (534)	0.64	755 (343)	1.74	2,046 (930)
11	1,100 (500)	0.64	708 (322)	0.64	702 (319)
12	1,030 (468)	0.81	829 (377)	1.45	1,489 (677)
13	955 (434)	0.16	154 (70)	0.48	462 (210)
14	884 (402)	0.97	860 (391)	0.81	717 (326)
15	807 (367)	0.65	526 (239)	0.16	132 (60)
Sum of milk loss per 100 cows			23,723 lb (10,783 kg)		33,169 lb (15,077 kg)
Difference in saleable milk per 100 cows			9,447 lb (4,294 kg)		
Value of additional saleable milk per cow			$28.97 US ($30.49 CDN)		
Cost of ITS per cow			$9.50 US ($10.00 CDN)		
Net benefit of ITS per cow			$19.47 US ($20.49 CDN)		

assignment of treatment at the cow level. This study employed the largest number of cows of all published studies on the use of an ITS. Due to the number of herds involved and the demands on participating producers that were judged feasible, as well as due to the budget available for the study, infection status at dry-off and just after calving were not measured. Also, a principal objective of the study was the analysis of the association of treatment with CM, which is more directly related to potential economic benefit where milk payment premiums for low SCC are not available, such as in Canada. Therefore, the association of treatment with new IMI through the dry period was not assessed.

The period of observation for the present study was the first 105 days of lactation, which is consistent with recent studies.[2,5] Others[8,16] used a 60 day observation period. Consistent with all similar studies, in the present study the risk of mastitis overall, and the effect of treatment with the ITS, was greatest in very early lactation (Figure 1).

Reduction in the incidence of clinical mastitis

This randomized clinical trial confirmed the reduction in the incidence of CM in early lactation associated with the addition of an internal teat sealant to IMM antibiotic treatment at dry-off. By all three of the measures used, cows treated with ADCT+TS had approximately 25% lower incidence of CM than those treated with ADCT alone. This magnitude of reduction in CM is between effects reported in studies under fairly similar conditions. Godden *et al*,[8] using a split-udder design, observed a significant reduction of 33% in the quarter case incidence of CM between dry-off and 60 DIM. Cook *et al*,[5] using a whole cow comparison in three herds, observed a tendency for reduction of 19% in the proportion of cows with at least one case of CM, and very similar to the present study, a tendency for reduced rate (delay in occurrence postpartum) of CM of 24% (HR = 0.76) over the first 100 DIM.

Influence of cow risk factors

Length of dry period and season of dry-off had no significant effect on outcomes of interest in this study. ADCT+ITS had no interactions with parity, season of dry-off or season at calving. Although the effect was greatest for cows that were dried off or calved in summer, the direction of the effect was the same in all seasons. Godden *et al*[8] observed a higher risk of experiencing a CM event between dry-off and 60 DIM for quarters dried off in May or June, compared to August.

Woolford *et al*[21] demonstrated by X-ray imaging that this ITS persists for at least 100 days after insertion. Berry and Hillerton[3] found that when the dry period lasted 10 weeks or longer, cows receiving ADCT+ITS had significantly fewer new quarter infections than those treated with ADCT alone (3.7% vs 6%, respectively). Although the number of cows limited the power to detect effects on CM, Berry and Hillerton[3] did not find a difference in the effect of the same ITS on CM with different lengths of the dry period. Similarly, there was no interaction of dry period length (between 28 and 120 days) with the effect of ITS on CM in the present study.

Influence of treatment on pathogens causing clinical mastitis

Approximately 80% of first cases of CM had samples taken to allow for description of pathogens involved. This was a better sample submission proportion by participating producers than experienced in a similar study of this ITS (45%[5]), though not as high as reported by Olde Riekerink *et al*[13] (96%). The proportion of samples with no bacterial growth (19%) was lower than in some reports from Canada, such as a report by Olde Riekerink *et al*,[13] but similar to others. The relatively higher prevalence of *S. aureus* among isolates may be one factor contributing to the lower prevalence of "no growth" results. In the present study, there were too few cases of most individual pathogens or pathogen groups for meaningful analysis or detection of less than very large differences. Other studies have reported pathogens associated with new IMI through the dry period and/or within a few days after calving rather than the results of bacteriologic culture from cases of CM. Several studies have reported a reduction in IMI with environmental streptococci in cows receiving an ITS.[5,8,21] However, in the present study there was no difference between groups in the proportion of cows that experienced CM from which streptococci were cultured. In the present study, there was a reduction in the proportion of cows that had a first case of CM from which coliform bacteria were cultured. Huxley *et al*[11] found a significant reduction in new IMI with *E. coli* in cows with consistently low SCC and no CM in the previous lactation treated with ITS alone rather than ADCT alone, but they did not find a difference in CM attributable to *E. coli*. As with other reports, there was limited statistical power for detection of pathogen-specific differences in CM, or no such data appear in other reports.

Infection of quarters in the dry period is associated with earlier postpartum occurrence of CM rather than IMI that occurred after calving.[9] In particular, coliform CM during the same period of interest as in the present study is associated with IMI during the dry period.[11] Therefore, it is likely that a decrease in IMI in the dry period, particularly with coliform bacteria, contributed to the lower incidence of CM among cows in this study that received an ITS in addition to ADCT.

Impact on reproduction

This study was the first to examine the possibility that a reduction in CM associated with addition of an ITS at dry-off might influence reproductive performance. This hypothesis was based on reports[1,17] of CM, especially preceding or soon after first insemination, being associated with poorer reproductive performance. There was no significant difference in time to pregnancy between treatment groups, although detection of a difference of approximately 10 days in time to pregnancy with survival analysis would require more cows.

Economics and application

The magnitude of the estimated increase in saleable milk (94.6 lb [42.9 kg] per cow on average) associated with the reduction in early lactation CM among cows treated with the ITS was nearly identical to that observed by Cook *et al*[5] (93.3 lb [42.3 kg] per cow) using a very similar study design. The net economic return of approximately $19 US ($20 CDN) per cow (approximately a 3-to-1 ratio of the gross benefit to the cost of the product) treated with the ITS was greater than the average return of $5.38 US (approximately a 1.7-to-1 gross benefit-to-cost) observed by Cook *et al.*[5] The difference is largely due to a substantially higher gross price for milk in the Canadian industry, offset slightly by a higher cost of the ITS. For the most conservative estimation, it might be assumed that additional milk production quota would have to be purchased to allow for sale of the additional milk available from prevention of CM by use of the ITS. In that scenario, the price for milk would be discounted by the principal and interest cost of purchase of additional quota, which would typically yield a net milk price of approximately $0.17 US/lb ($0.40 CDN/kg), reducing the net benefit of using ITS to $6.80 ($7.16 CDN) per cow, or a 1.7-to-1 gross benefit-to-cost, the same as found by Cook *et al.*[5] Herd-specific net benefits would lie between these values, depending on quota holdings, available housing space, feed, cow inventory, and management strategies. For established herds of stable size, the higher estimate is likely appropriate.

Cook *et al*[5] indicated some differences among three herds in the magnitude of reduction of CM and the profitability of addition of this ITS to ADCT, likely associated with the overall risk of mastitis in early lactation. The present field trial was designed as a cow-level study. A herd-level study of factors (eg, a possible threshold incidence rate of CM in early lactation, mastitis pathogen profile, housing and bedding types, the value of milk) influencing the effect and economics of implementation of an ITS as part of drying off would be very useful to help inform managers' decisions, but would require substantially more herds. Until such data are available, managers and veterinarians should consider the variables above, among others, for herd-specific decisions. Cow-level studies, including this one, are consistent in the direction, and broadly similar in the magnitude, of the effect of reducing IMI and CM associated with addition of an ITS to ADCT.

Conclusions

Under field conditions, using ADCT+ITS at dry-off lowered the incidence of CM between calving and 105 DIM by approximately 25%. Prevention of mastitis depends on many factors in addition to dry-cow therapy, including environmental hygiene, drying-off technique, nutrition, vaccination, and close monitoring of cows during vulnerable periods. However, on average in the present study, adding an ITS to the established dry-cow treatment profitably reduced the incidence of CM.

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Endnotes

[a]DSA LV; DS@HR, St-Hyacinthe, QC
[b]NovoDry, Pfizer Animal Health, Kirkland, Canada
[c]CefaDri, Wyeth Animal Health, Guelph, Canada
[d]Orbeseal®, Pfizer Animal Health, Kirkland, Canada
[e]VALACTA, Ste-Anne de Bellevue, QC
[f]PML Microbiologicals, Wilsonville, OR
[g]BioMérieux, Marcy l'Étoile, France
[h]Difco Laboratories, Detroit, MI
[i]SAS Institute, Cary, NC
[j]Spreadsheet available at http://www.vetmed.wisc.edu/dms/fapm/fapmtools/milk_quality.htm

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