

Intramammary Infections and Somatic Cell Counts across the Dry Period

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Take Home Message

- Use of intramammary antimicrobial dry cow treatment (DCT) is fundamental for effective mastitis control but even with the use of DCT, about 25- 30% of cows may have quarters that maintain chronic intramammary infections across the dry period
- Quarters with chronic intramammary infections have 4 times increased risk of having clinical mastitis in the current lactation as compared to uninfected cows
- The evaluation of somatic cell count in fresh cows should not be performed until at least 5 days post-calving and the best use of these values may be to compare quarter SCC values between dry off and post-calving with the objective of identifying chronically infected quarters for potential interventions

Introduction

The dry period is known to be a major determinant in mastitis epidemiology and production of high quality milk. During the dry period, the mammary gland experiences physiologic changes which result in increased susceptibility for development of new intramammary infections (IMI) (Oliver and Sordillo, 1988). Existing IMI (from the previous lactation) and new infections (that originated between drying off and calving) both contribute to the occurrence of subclinical and clinical mastitis in subsequent lactations (Green et al., 2007). Mammary glands which become infected during the dry period produce less milk (Oliver and Sordillo 1988). Therefore, understanding the epidemiology and dynamics of bacterial infections that occur during the dry period is critical for successful control of mastitis.

The development of IMI during the dry period is influenced by individual cow risk factors, the intensity of exposure to potential pathogens, and the effectiveness of interventions (such as antibiotic therapy or teat sealants) (Green et al., 2007). The dry period can be divided into 3 distinct phases (active involution, steady involution and colostrogenesis). The risk of developing mastitis is greater during the periods of active involution and colostrogenesis. Active involution is characterized by regression of mammary tissue, changes in composition of mammary secretion and rapid decline in milk production. Physiological events that contribute to greater susceptibility to IMI include termination of the flushing effect of milking on bacteria present in the mammary gland, increased mammary pressure and subsequent leakage of milk and reduction and change in the population of defense cells and biochemical characteristics of the mammary secretion.

The increased risk of IMI during active involution is well recognized and is one reason that antimicrobial treatments during the dry period are recommended. Antimicrobial DCT has been reported to cure 70 – 98% of existing IMI at drying off and to reduce new IMI by 50 – 75% during the dry period (Smith et al., 1985). Robert et al. (2006) performed a meta-analysis to evaluate differences in the effectiveness of DCT in reducing the incidence of IMI during the dry period among pathogens. Reductions ranged from 68% for IMI caused by streptococci to 23% for IMI caused by *Staph aureus*. Similarly, quarters that received both intramammary dry cow

therapy containing long-acting antibiotics and internal teat sealants were 30 - 59 % less likely to develop a new IMI between dry off and 1 to 3 days in milk, as compared to quarters treated with DCT alone (Godden et al., 2003 and Cook et al., 2005). In spite of these interventions, the frequency of mastitis is greatest in early lactation and indicative that our current preventive strategies are not sufficient. The objective of this paper is to review the status of IMI across the dry period and provide preliminary recommendations for potential management strategies useful to reduce mastitis in subsequent lactations.

Intramammary Infection and the Dry Period

The prevalence of existing IMI at drying off is one factor that influences the incidence of IMI during the dry period. In herds that have controlled mastitis caused by *Staph aureus* and *Streptococcus agalactiae*, the prevalence of IMI has been reported to range from 12-28% and 14-20% for quarters sampled at dry off and calving, respectively (Cook et al., 2005, Hogan, et al., 1989, Oliver and Mitchell, 1983). Coagulase-negative staphylococci (CNS) are consistently reported to be the most commonly recovered pathogens.

The incidence of IMI acquired during the dry period varies among herds. The incidence of quarter IMI during the dry period ranged between 10 and 17%, with most of the infections caused by environmental organisms (Eberhart, 1986; Oliver, 1998; Dingwell et al., 2002, Green et al., 2005). Of these infections, 50 to 63 % persisted through the dry period and were present at calving (Oliver and Mitchell, 1983). However, some bacteria isolated in early lactation have been considered to be new IMI acquired during the dry period (Oliver and Mitchell 1983, Smith et al., 1985; Green et al., 2005).

Streptococci thrive in environmental conditions that are often present in dry cow housing areas and approximately 55% of environmental streptococcal IMI present in the first half of the dry period persisted into the following lactation (Todhunter et al., 1995). Streptococcal infections progressively increased across the dry period whereas the rate of new coliform infections was greater during the first and last quarter of the same period. Cows that had environmental pathogens (such as *E. coli*, *Klebsiella spp*, *Streptococcus dysgalactia* and *Streptococcus uberis*) isolated from milk samples obtained at dry off were many times more likely to have a clinical case of mastitis during the next lactation as compared to uninfected cows (Bradley and Green, 1999; Green et al., 2005).

Risk Factors for IMI during the Dry Period

Rapid growth of mammary tissue and production of large amounts of secretion are observed in the last 2 weeks of gestation. The resultant pressure can cause leakage of colostrum and variations in the teat canal which may increase susceptibility to IMI. Teat-end bacterial populations, integrity of the teat-end, and timely formation of the keratin plug are important risk factors that also affect the probability of IMI during the dry period (Oliver and Sordillo, 1988). Closure of the teat-canal can occur as soon as 16 days after dry off but 3-5% of quarters never close and 97% of clinical mastitis that occurred during the dry period occurred in quarters that did not have a keratin plug (Williamson et al., 1995). Failure to develop a keratin plug has been associated with high milk production. Teats were still open 6 weeks after dry off for half of cows that produced more than 21 kg of milk on the day before lactation ended (Dingwell et al.,

2003). When lactation ends, teats are no longer routinely disinfected, which increases exposure to opportunist bacteria such as CNS and other environment pathogens.

Increasing parity has been reported as a risk factor for new dry period IMI (Oliver, 1987), suggesting that anatomical or intramammary defense mechanisms of cows may deteriorate with age. First parity cows experienced the lowest incidence of new IMI during the dry period, as compared to cows in second and third or more lactations (11.9%, 20.9% and 18.9%, respectively; Dingwell et al., 2002). Existing subclinical infections or decreased patency of the teat sphincter may contribute to increased susceptibility.

Several risk factors for IMI are associated with lactating and dry cow housing management practices (Dingwell et al., 2004; Green et al., 2005 and 2007). Udder cleanliness and exposure to moisture, mud, and manure in cow housing areas, as measured by hygiene scoring systems, can influence the rate of subclinical and clinical mastitis of both dry and lactating cow.

Evaluating the Impact of Subclinical Mastitis across the Dry Period

From August, 2005 to January, 2007, all dairy cows from the University of Wisconsin dairy herd were enrolled at dry off in a study to evaluate the origin of IMI in subsequent lactations. All cows received intramammary antibiotic DCT and teats were infused with an internal teat sealant. Quarter milk samples were collected from all quarters at dry off, post-calving (6 days in milk), at the first DHI test and before treatment of all cases of clinical mastitis that occurred during the first 4 months of the subsequent lactation. Microorganisms were identified according to NMC procedures and quarter SCC were determined. Monthly cow-level SCC values were obtained from DHIA data. A threshold of 200,000 cells/mL was used to define quarters with likely subclinical infections. At quarter level, chronic infections were defined as quarters that exceeded the SCC threshold both at dry-off and calving; new infections were defined as quarters that were below the SCC threshold at dry off and exceeded the threshold at the post-calving sample. Cures were defined as quarters that were above the threshold at dry-off but not at calving. Uninfected quarters had SCC below the threshold at both periods. Logistic regression models and survival curves were used to analyze the data.

Complete data was obtained from 205 cows and 68 first cases of mastitis occurred in 47 cows. The profile of pathogens isolated from clinical cases was different from pathogens isolated from subclinical cases. CNS were the most prevalent pathogens isolated from subclinical IMI whereas Gram negative pathogens were the most common outcome from clinical IMI (Table 2).

Table 2. Profile of microbiological results from all sampling periods.

Sampling Period	No Growth	Microbiological Result (% of quarters)			
		Staph spp. ^a	Strep spp. ^b	Gram neg.	Others
Dry Off (n = 804)	702 (87%)	59 (7%)	28 (3%)	2 (<1%)	13 (2%)
Calving (n = 808)	753 (93%)	24 (3%)	15 (2%)	7 (<1%)	9 (1%)
1 st test (n = 805)	737 (92%)	26 (3%)	21 (3%)	12 (1%)	9 (1%)
1 st Clinical (n=66)	16 (24%)	8 (12%)	17 (26%)	19 (29%)	6 (9%)

^a *Staphylococcus aureus* was isolated only from clinical cases (n=4); ^b *Streptococcus agalactia* was not isolated.

The prevalence of quarter-level subclinical IMI at all sampling periods was always greater when estimated using SCC, as compared to microbiology (Table 3). The sensitivity and specificity of

quarter-level SCC for detecting subclinical IMI, as diagnosed by microbiology, were 0.64 and 0.66 at dry-off, 0.69 and 0.84 at calving 0.65 and 0.93 at the first DHIA test, respectively.

Table 3. Quarter prevalence of IMI across the dry period as estimated by bacteriology or SCC threshold of 200,000cells/ml

	Prev.DO ^a	Prev.at PC ^b	Prev.at FT ^c	Chronic IMI ^d	New IMI ^e	Cured IMI ^f
Bacteriology	102(12.8%)	55(6.9%)	68(8.5%)	10(9.9%)	45(6.5%)	91(90.1%)
Quarter SCC	298(37.3%)	155(19.3%)	91(11.4%)	76(25.5%)	79(15.8%)	225(74.8%)

^aprevalence at dry off; ^bpost-calving; ^cFirst DHIA test; ^dSCC>200,000 both at dry-off and calving; ^eSCC <200,000cells/ml at dry off and >200,000cells/ml post-calving sample; ^fSCC>200,000cells/ml at dry-off but not at calving

Survival curves were used to assess time to the first case of clinical mastitis in the first 120 days of the subsequent lactation for quarters stratified into 4 groups based on SCC changes across the dry period: A) chronic IMI; B) cured IMI; C) uninfected and D) new IMI (Figure 1). Twenty one percent of the quarters with chronic IMI developed a case of clinical mastitis, in contrast to 5.0% of uninfected quarters ($P < 0.01$). Quarters with chronic IMI were 4.3 times more likely to develop a clinical case than uninfected quarters (Odds Ratio 4.3; 95% CI: 1.7 -10.6).

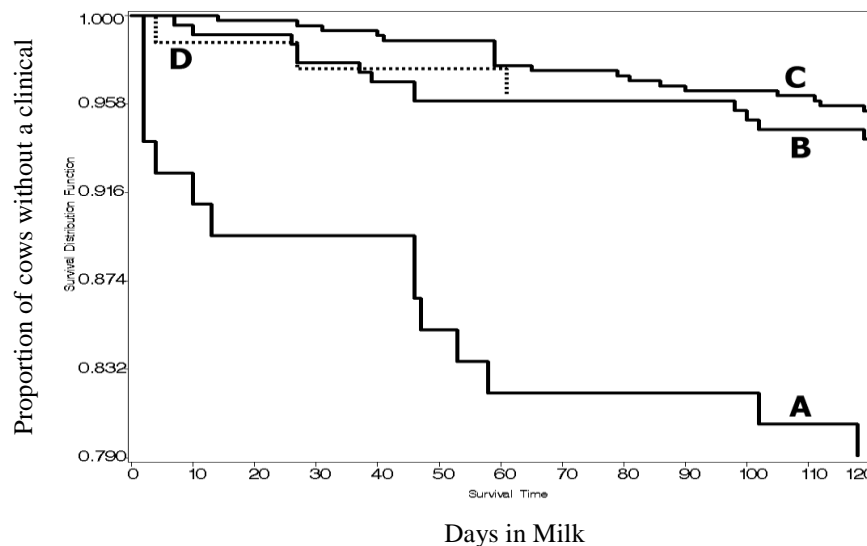


Figure 1. Kaplan-Meier survival curves. **A**: Chronic IMI (n = 67); **B**: cured IMI (n = 222); **C**: uninfected quarters (n = 420) and **D**: new IMI (n = 79).

Sixty percent of the quarters which were chronically infected across the dry period (using microbiology) were correctly identified as chronic by using a SCC threshold of 200,000 cells/ml and 91% of the quarters which were not chronically infected (using microbiology), were correctly identified using that threshold. The use of SCC to detect new or cured infections was less accurate, with sensitivities of only 58%, and 48%, respectively.

Screening Fresh Cows for Subclinical Mastitis

The identification of SCC status across the dry period (**quarters** with estimated chronic, new and cured IMI, as well as uninfected quarters) can be a valuable tool for monitoring milk quality. Our data suggests that quarters with SCC $\geq 200,000$ cells/ml at both dry-off and post-calving are at

greater risk for clinical mastitis and are more likely to be subclinically infected at the first DHIA test of the subsequent lactation.

It is important to recognize that SCC values determined immediately after parturition are not necessarily predictive of infection. The SCC of many healthy quarters are increased during the first week post-calving. In unpublished data, we collected quarter milk samples from cows (n = 200) during the first week post-calving. We performed cultures and CMT tests and determined the SCC of duplicate quarter milk samples. For both healthy and infected quarters, there was a strong correlation between the day of sampling and the results of diagnostic testing for both SCC and bacteria (Table 3). Based on this and other data, it is unlikely that SCC values or CMT tests obtained before day 5 can be used to accurately identify infections.

Table 3. Outcomes of early postpartum diagnostic testing (Ruegg, Rieth and Hulland, 2005)

	Sampling Day Postpartum						
	2	3	4	5	6	7	8
Number ¼ s	183	96	112	56	75	157	110
SCC (cells/ml x1000)	725	591	571	250	355	269	152
Percent of quarters > 200,000 cells/ml	61%	38%	36%	18%	15%	18%	9%
CMT positive (%)	49%	31%	34%	14%	15%	19%	9%
Major pathogens recovered (%)	4%	1%	5%	0%	5%	2%	1%
Minor pathogens recovered (%)	11%	14%	13%	5%	9%	5%	5%

Recommendations

One management objective for the dry period is to minimize the number of quarters that are infected at calving. One of the most effective strategies is the use of dry cow therapy. Administration of DCT to all quarters is successful in curing many existing subclinical infections as well and offering short-term protection against new IMI when susceptible pathogens invade the gland during the early dry period.

The use of teat sealants is another effective strategy directed toward reducing exposure. External teat sealants generate a latex, acrylic, or other polymer-based film over the teat that prevents entry of pathogenic bacteria into the teat canal. Although research data indicated a substantial reduction of new IMI at calving (Timms et al., 1997), the lack of appropriate adherence of the product to the teats and consequent extra labor and facilities required to frequently reapply them, may limit their potential for routine use on dairy farms. The one commercially available internal teat sealant is an inert viscous paste composed of bismuth subnitrate (Orbeseal or Teatseal, Pfizer). Orbeseal is administered into the teat sinus after dry off with the objective of preventing pathogens from entering. The sealant resides in the teat canal for the duration of the dry period and is removed at calving by manual stripping. Reduction in the incidence of IMI during the dry period has been demonstrated (Godden et al., 2003).

The use of CMT or other screening tools to identify infected quarters post-calving and administer antibiotic treatments has been advocated ("Fresh-start" programs). Initial research efforts have not indicated that the strategy of treating high SCC quarters in the immediate post-partum period results in reduced prevalence of subclinical mastitis nor increased milk yield (Wallace et al., 2003). The failure to demonstrate efficacy of this strategy is probably related to the high

prevalence of infections with minor pathogens, the high rate of spontaneous cure that occurs in early lactation and the inability of SCC values to differentiate truly infected quarters before at least day 5 post-calving. Our research indicates that quarters that have increased SCC both before and after calving (“chronic”) are at very high risk of mastitis in the current lactation. Based on this research, a more effective post-calving strategy may be to record SCC (or CMT) values before dry off, and again post-calving (day 5-7). While the research has not been performed yet, administration of intramammary antibiotics to quarters that have maintained high SCC across those periods may be a more appropriate strategy.

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