Effectiveness of Antibiotic Infusion at Drying-Off in Preventing New Mastitis Infections in Cows*

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Bovine mastitis is responsible for greater economic loss than any other single disease affecting dairy cattle. Losses may be attributed to reduced milk yield, altered milk composition, veterinary fees, cost of drugs, increased culling rate and cost of replacement cows (8).

Most mastitis causing bacteria (*Staphylococcus aureus, Streptococcus uberis, Strep. dysgalactiae, Pseudomonas aeruginosa, Escherichia coli, Klebsiella species,* and *Corynebacterium pyogenes*) are widely distributed in the environment, so that complete eradication appears to be impossible (1,7,5). *Strep. agalactiae* is limited to the mammary gland with many opportunities existing for transfer from cow to cow. Therefore, the udder of a dairy cow is constantly exposed to a number of species of pathogenic bacteria.

Major emphasis in the past was directed toward the elimination of existing mastitis infections during lactation (10,2,8,3). More recently, attention has focused on elimination of existing infections or prevention of new infections during the non-lactating period (4,14,18). It is estimated that 50 to 80% of all new mastitis infections begin during the dry period; therefore, prevention of new infections during this period would substantially reduce the mastitis problem (13,16,18).

The purpose of this study was to evaluate the effectiveness of antibiotic infusion into all quarters of cows at drying-off in preventing new infections under the environmental and management conditions prevailing in the Southwest.

Materials and Methods

Prior to drying-off, quarter milk samples from all cows in the Oklahoma State University dairy herd were examined for presence of mastitis causing bacteria. Cows found to be negative (59 Ayrshire, 13 Guernseys, 23 Jerseys, and 77 Holsteins) were blocked on the basis of number of lactations completed (one, two, three or more) and randomly assigned to treatment groups. Micrococci, diphtheroids, and *Staph. epidermidis* were recorded as nonpathogens. Cows having quarters with these organisms were regarded as negative and were included in the experiment.

The treatments were: (a) control, no infusion and (b) intramammary infusion of 500 mg. benzathine cloxacillin[a] into each quarter after the last milking of the lactation period. All cows in both groups were teat dipped with an iodine solution[b] (10,000 ppm available iodine) once a day for seven days after drying off. Throughout the dry period, they were maintained in a pasture separate from the milking herd and periodic examinations of udders were made for inflammatory changes such as heat, swelling, and pain.

Cows were allowed to calve in a pasture or an open shed regardless of the time of year. Calves remained with the cows until the next regular milking after calving (less than 12 hours). For three or four days after calving, freshened cows were kept separate from the milking herd.

Standard management procedures included proper maintenance of milking equipment (Surge[c] low line milking system with automated udder washing stalls), use of strip cup for detection of clinical mastitis, drying each udder with single service paper towels, use of acceptable milking technique, and teat dipping with an iodine solution

[a] *Bristol Laboratories, Division of Bristol-Myers Co., Syracuse, New York. An experimental drug presently being evaluated by FDA.*
[b] *"Bovadine", West Agro-Chemical Products, Inc. Subsidiary of West Chemical Products, Inc., Long Island, New York.*
[c] *Babson Bros. Co., Oak Brook, Illinois.*

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(10,000 ppm available iodine) after each milking.

Infection status was determined by bacteriological examination of quarter milk samples at drying off, 4 to 10 days post-partum, one month post-partum, and whenever clinical mastitis was detected. A single sample of foremilk from each quarter was obtained on one day and duplicate samples were taken two to five days later.

Procedures for sample collection included washing of udders, drying with individual paper towels, and scrubbing the teat end thoroughly with 70% alcohol. Samples were collected prior to attachment of the milking machine. When clinical mastitis was detected, a duplicate sample of foremilk from each quarter was taken before treatment, using the same procedures.

Samples were cultured within four hours following the sampling period. After shaking the samples for five seconds with a mechanical mixer, 0.02 ml of milk was streaked onto one-half of a petri dish containing 5% bovine blood agar. After 24 hours of incubation at 36°C., the plates were examined for the number of colony forming units of Staphylococci, Streptococci, or other organisms. The number of colonies were recorded, and the plates were incubated for an additional 24 hours and observed for growth of additional colonies. Procedures to identify specific groups or species of mastitis causing microorganisms, and the criteria for classifying a quarter infected, were those published by the Research Committee of the National Mastitis Council (2).

Results and Discussion

Infusion of benzathine cloxacillin into the udder of cows at drying-off significantly reduced ($P < .01$) the number of cows developing new mastitis infections during the dry period and the initial 4 to 10 days of the subsequent lactation (Table 1). Likewise, the number of quarters with new infections was significantly reduced (P .001) by this treatment. The number of previous lactations did not significantly influence the effectiveness of antibiotic infusion in preventing new infections. Thus, in a program of dry cow prophylaxis for mastitis, infusion of all quarters of all cows, without regard to age, appears to be indicated.

Table 1

Number of New Infections Developing During the Dry Period

Item	Cows		Quarters	
	Control	Infused	Control	Infused
Number of experimental units	85	87	339[a]	347[a]
Clinical infections detected during dry period	1	0	2	0
Additional infections detected up to 4 to 10 days post-calving	15	4	20	5
Total new infections	16	4	22	5
Percent new infections[b]	18.8	4.6	6.5	1.4

[a]One blind quarter.
[b]Difference between groups statistically significant for cows ($P < .01$) and quarters ($P < .001$).

Only 2 of 25 new infections in quarters were detected by clinical observation during the dry period. Presumably, at least part of the other 23 infections first detected 4 to 10 days post-calving also occurred before calving. Neave, et al. (11), suggested that the first few days after calving is one period when cows are particularly vulnerable to new infections. However, since benzathine cloxacillin would be expected to persist in the udder for only four weeks of the dry period, it would be difficult to account for its effectiveness in preventing new infections in this trial had they occurred after calving.

A surprisingly small number of experiments have been reported in which infection rate in cows infused with antibiotic at drying-off was compared to a control group without infusion. Moreover, a large amount of variation in the effectiveness of antibiotic infusion may be noted in a summary of these experiments (Table 2). Oliver, et al. (13), noted an 83% to 100% reduction in new infections by infusion of procaine penicillin G and dihydrostreptomycin in two separate trials, which agrees closely with the results of the present study. The relatively low reduction, i.e., 41%, noted by Ward and Schultz (21), could be attributed to ineffectiveness of neomycin sulfate against gram-positive microorganisms, as suggested by Sanderson (17) and Uvarov (20). In one experiment, Pearson and Wright (14) initiated treatment part way through the non-lactating period, and within-cow cross infection may have reduced the effectiveness of infusion in a second experiment. In the experiment by Thoreson (19), use of poor milking facilities during remodeling of the milking parlor may have caused a high rate of new infections in both treated and control cows within a few days after calving.

In experiments where antibiotic infusion plus teat dipping after the last milking was compared to controls having neither of these, reduction in rate of new infection from 45 to 82% have been reported. Smith, et al. (18), noted that benzathine cloxacillin was more effective than sodium cloxacillin (82 vs. 65% reduction in infection rate), possibly because of the relatively short duration of

Table 2

Summary of Reported Results on Antibiotic Infusion to Prevent Mastitis Infection in the Dry Period

Investigators	No. of Cows or Quarters	Treatment	Reduction in Infection Rate, %	New Infection Rate in Controls, %	Remarks
Experiments with antibiotic infusion as only variable:					
Sinkevich et al. (present study)	655 quarters	0.5 g benzathine cloxacillin	78	6.5	All quarters teat dipped
Oliver et al. (1962)	37 quarters	200,000 units procaine penicillin G and 200,000 units di-hydrostreptomycin	83	16.2	Within-cow comparison; all quarters teat dipped
	37 quarters	100,000 units procaine penicillin G and 100,000 units di-hydrostreptomycin	100	35.1	Same as above
Ward and Schultz (1973)	402 quarters	0.5 g neomycin sulfate	41	9.5	Two teats of all cows teat disinfected; only these were used in this comparison
Pearson and Wright (1969)	369 quarters	0.3 g procaine penicillin G	15.5	16.2	Experiment initiated part way through nonlactating period
		0.5 g benzathine cloxacillin	1.79	12.3	Within-cow (right vs. left side) comparison
Thoreson (1973)	160 quarters	0.5 g benzathine cloxacillin	0	13.1	No cows teat dipped; poor milking facilities
Experiments with antibiotic infusion and teat dipping versus controls:					
Smith et al. (1967)	1782 quarters	1.0 g benzathine cloxacillin	82	9.5	Controls not teat dipped
		0.2 sodium cloxacillin	65.3	9.5	Same as above
Rosenzuaig and Mayer (1970)	112 cows	0.5 g benzathine cloxacillin	78.9	22.3	Same as above, plus poor management and milking conditions
Eberhart and Buckalew (1972)	680 quarters	200,000 units procaine penicillin G and di-hydrostreptomycin	56.1	11.6	Same as above, plus cows treated during 1st and 2nd week of dry period
Langley et al. (1971)	314 quarters	0.5 g benzathine cloxacillin	45	3.8	Within-cow (right vs. left side) comparison on controlling Staph. aureus

the sodium salt in the dry udder. Within-cow cross infection from untreated to treated quarters may have lowered the apparent effectiveness of benzathine cloxacillin in reducing new *Staph. aureus* infections in the trial by Langley, et al. (9).

Considering all the experiments in which antibiotic infusion at drying-off has been evaluated, there was no definite relationship between level of infection in the herds, as measured by rate of infection in the control group, and effectivenss of antibiotic infusion in reducing new infection rate. Thus, the practice of infusing cows at drying-off appears to be beneficial even under conditions where a relatively low new infection rate can be expected. Factors which may influence the efficacy of dry cow infusion include dose, base, and type of the various antibiotic preparation. Whether or not all cows in a herd should be infused depends upon the feasibility of sampling every cow near drying-off to determine infection status, number of new infections expected during the dry period, cost of the drug, and likelihood that the antibiotic infusion would be done in an acceptable manner.

The majority of the new infections up to 4 to 10 days post-calving were determined by bacteriological examination of quarter milk samples (Table 3). Ninety percent of the new infections in cows were determined in this manner, whereas only one-fourth were clinical cases of mastitis. On a quarter basis, 77.8% of the infections were

Table 3

Infections Determined by Bacteriological or Clinical Means up to 4 to 10 Days Post-calving

Method of Detection	No. of Cows or Quarters	Percent Detected By Method Designated
Cows		
Bacteriological only	15	75
Bacteriological and clinical	3	15
Clinical only	2	10
Quarters		
Bacteriological only	18	67
Bacteriological and clinical	3	11
Clinical only	6	22

detected by bacteriological examination, and only 33.3% by observation of clinical mastitis. Similarly, Edwards and Smith (6) found 20.5% of the new infections in cows at calving were detected by clinical observation. Thus, it appears that quarter milk samples from all freshened cows would need to be examined bacteriologically to detect a large majority of new infections. Otherwise, the majority of new infections would advance to a greater degree of severity, possibly causing severe damage to the secretory tissue before detection during the ensuing lactation.

In the infused cows which did develop infections during the dry period or during the first month of lactation, the same species of common mastitis producing organisms were isolated as were present in the herd prior to initiation of this experiment. There was no evidence of an increase in the occurrence of the less common species of bacteria which occasionally cause mastitis. This result is in agreement with reports of other investigators (4,13,14,17).

Considering only cows free of mastitis at 4-10 days post-calving, infusion before the dry period did not appear to influence susceptibility to infection during the first month of lactation. During this period, there was a similar percentage of new infections in cows which had been infused during the previous dry period and control cows (10.8 vs. 8.7% respectively). New infection rate in the treated and control quarters was 3.6 and 2.2%, respectively. A few investigators (3,5,10) suggested that untreated quarters which possess non-pathogenic bacteria at drying-off may have a lower rate of new infection than treated quarters in the ensuing lacatation. They theorized that the presence of non-pathogenic bacteria in the untreated quarter may initiate counts of 300,000 to 500,000 somatic cells per ml of milk which would act as an effective barrier against invasion into the udder of certain pathogenic bacteria. No evidence was obtained in the present study to support this idea.

In two experiments in which the effectiveness of post-lactation teat dipping for preventing new infection has been evaluated (12), this practice has proven to be beneficial. In contrast, other workers (21,22) observed no reduction in infection rate due to teat dipping after lactation was terminated. More research is needed to establish whether or not this practice has merit.

Summary

Infusion of each quarter of the udder at drying-off with 500 mg benzathine cloxacillin significantly reduced ($P < .01$) the rate of new mastitis infection in cows up to 4 to 10 days post-calving. Rate of new infection was 18.8% in control cows compared to 4.6% in infused cows. Seventy-five percent of the new infections in cows and 66.7% in quarters were detected only by bacteriological examination. No increase in the less common species of mastitis producing bacteria occurred as a result of dry cow infusion. The incidence of new infections in the period from the first post-calving sampling up to 30 days of lactation was similar in both groups.

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