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Technical Note: Therapeutic Cessation of Lactation of *Staphylococcus aureus*-Infected Mammary Quarters

J. R. Middleton* and L. K. Fox†
†Department of Veterinary Clinical Sciences,
Washington State University, Pullman 99164-7060
*Department of Veterinary Medicine and Surgery,
University of Missouri, Columbia 65211

ABSTRACT

The objective of the present study was to compare the ability of chlorhexidine and povidone-iodine to cause cessation of lactation in *Staphylococcus aureus*-infected mammary quarters, assess milk production in the treated quarter in the subsequent lactation, and evaluate whether microbiological cure was obtained. Fourteen mid- to late-lactation Holstein-Friesian dairy cattle from the Washington State University dairy herd with single mammary quarter *S. aureus* intramammary infections were studied. Cows were randomly assigned to one of two treatment groups, povidone-iodine or chlorhexidine. Cows in the povidone-iodine group were infused with 120 ml of 5% povidone-iodine solution (0.5% iodine) after complete milk-out. Chlorhexidine-treated cows were infused with a proprietary chlorhexidine suspension after two milkings 24 h apart. Treated mammary quarters were not milked for the rest of the lactation. Milk production from each mammary quarter (kg of milk/quarter) was measured using in-line volume flow meters for 5 consecutive days before treatment and again at the start of the subsequent lactation. Povidone-iodine caused permanent cessation of lactation in the treated quarter, whereas 71% of the chlorhexidine-treated mammary quarters returned to function in the subsequent lactation. Hence, if the primary objective is to eliminate the mammary quarter from lactation, and thereby presumably lower the risk of herdmates acquiring new *S. aureus* intramammary infection, then povidone-iodine appears to be the best of the two methods. No difference in total milk production between lactation one and two in either group was found, suggesting that permanent loss of a quarter was not detrimental to overall milk production.
(**Key words:** *Staphylococcus aureus*, mastitis, therapy)

Abbreviation key: MWD = milk weight difference.

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Corresponding author: L. K. Fox; e-mail: fox@vetmed.wsu.edu.

The Washington State University dairy herd experienced an outbreak of mastitis caused by a single strain of *Staphylococcus aureus* in the face of routine contagious mastitis control procedures (Smith et al., 1998). To prevent the outbreak from escalating, additional control procedures were needed. The cow's mammary gland is a major reservoir for *S. aureus* (Roberson et al., 1993). Hence, control measures aimed at eliminating the mammary quarter as a reservoir for infection may be useful in decreasing the incidence of *S. aureus* IMI. A review of the current veterinary literature revealed a single study evaluating therapeutic dry-off of mammary quarters (Boddie and Nickerson, 1993), and the authors concluded that chlorhexidine diacetate could be used to permanently dry-off chronically infected mammary quarters. Veterinarians have used both povidone-iodine and chlorhexidine to cease lactation in chronically infected mammary quarters for many years and have anecdotally reported return to function of treated quarters in the subsequent lactation. To date, we have found no studies that evaluated the ability of a therapeutically dried mammary quarter to return to function in the subsequent lactation and be cured of *S. aureus* IMI. The primary objective of the present study was to compare the ability of chlorhexidine and povidone-iodine to cause cessation of lactation in mid to late lactation in *S. aureus*-infected mammary quarters, in hope of removing the infected mammary quarter as a potential reservoir of infection to other cattle. Additional objectives were to assess milk production in the treated quarter in the subsequent lactation and evaluate whether a microbiological cure could be attained.

Fourteen mid- to late-lactation Holstein-Friesian dairy cattle from the Washington State University dairy herd with single mammary quarter *S. aureus* IMI were studied. The study was performed according to the guidelines of the Institutional Animal Care and Use Committee. *Staphylococcus aureus* IMI was determined from monthly mammary quarter milk cultures. Milk samples were aseptically collected and cultured in ac-

cordance with established guidelines (National Mastitis Council, 1990). *Staphylococcus aureus* IMI was defined as two out of three consecutive positive cultures. Cows were randomly assigned to one of two treatment groups, povidone-iodine or chlorhexidine, such that every other cow received chlorhexidine. Treatments were administered aseptically by intramammary infusion into the *S. aureus*-infected quarters.

All cows were treated with 600 mg of flunixin meglumine (Banamine, Schering Plough, Kenilworth, NJ) intramuscularly 10 to 15 min before infusion of either povidone-iodine or chlorhexidine to minimize udder inflammation and counteract the effects of any aberrant endotoxin or pyrogens introduced during the infusion. Cows in the povidone-iodine group were infused with 120 ml of 5% povidone-iodine solution (0.5% iodine) (Betadine Solution, Purdue Frederick, Norwalk, CT) after complete milk-out. Chlorhexidine-treated cows were infused with a proprietary chlorhexidine suspension, 1 g of chlorhexidine in 28-ml base, (Nolvasan Suspension, Fort Dodge Animal Health, Fort Dodge, IA) after two milkings 24 h apart. Treated mammary quarters were not milked for the rest of the lactation. The degree of mammary quarter inflammation noted following infusion was minimal. All milk from treated cows was withheld from the bulk tank for 96 h postinfusion. All untreated quarters were infused with a dry cow intramammary antibiotic (Dry-Clox, Fort Dodge Animal Health, Fort Dodge, IA) at the end of the normal lactating period. To assess whether a microbiologic cure had been obtained, we collected quarter foremilk samples monthly for the first 3 mo of the subsequent lactation and cultured them for *S. aureus*. Cows with three consecutive negative milk cultures for *S. aureus* were presumed to have a microbiologic cure.

Cows were milked twice daily. Milk production from each mammary quarter (kg of milk/quarter) was measured once daily using in-line volume flow meters (Tru-Test Milk Meter, Tru-Test, New Zealand) for 5 consecutive days before treatment. Mammary quarter milk weights were measured again at the beginning of the subsequent lactation once daily for 5 consecutive days to assess return to function of the chlorhexidine or povidone-iodine treated quarter. Mean milk production was calculated as the arithmetic mean of five consecutive milk weight measurements from each mammary quarter. The sum of the milk production from all four quarters was also averaged over the five consecutive milk weight measurements in each lactation. Milk weight difference [**MWD** = mean milk weight (kg) in the uninfected contralateral control quarter – mean milk weight (kg) in the infected quarter] was calculated for each cow. The lactation in which the treatment was administered was defined as lactation one and the lactation subsequent to treatment was designated lactation two. Student's paired *t*-test ($P < 0.05$) was used to assess for significant differences between lactation one and two in each group.

Results are summarized in Table 1. None of the cows in the povidone-iodine group produced milk in the treated quarter in the subsequent lactation, whereas as five of seven (71%) cows in the chlorhexidine group produced milk in the next lactation. There was no significant difference in MWD in the chlorhexidine group ($P = 0.1316$) between lactations, whereas the MWD was greater after treatment in the povidone-iodine group ($P = 0.0007$). No significant difference in total milk production between lactations one and two was found in either povidone-iodine- or chlorhexidine-treated groups ($P = 0.2979$ and $P = 0.3475$, respectively). Microbiologic cures were obtained in four of seven (57%) cows treated with chlorhexidine. No microbiologic cures were obtained in the povidone-iodine group.

A nontreated control group was not used in the present study because in the herd studied we wanted to achieve a rapid cessation of lactation of the infected quarter in mid to late lactation to reduce the reservoir of infection to other cattle. Additionally, cattle with single mammary quarter infections caused by *S. aureus* were limited, and the authors felt it more advantageous

Table 1. Mean milk weights, mean milk weight differences, and mean total milk production for cows in each treatment group. Standard deviations are shown parenthetically. Milk weights represent once daily measurements or approximately half the daily production.

		Mean once daily milk production (kilogram)			
Treatment	Sample period	Infected	Control	Difference	Total
Povidone-iodine (n = 7)	Lactation 1 (before)	1.6 (1.7)	3.2 (2.0)	1.6* (1.0)	13.1 (4.0)
	Lactation 2 (after)	0.0 (0.0)	4.5 (1.5)	4.5* (1.5)	14.5 (4.5)
Chlorhexidine (n = 7)	Lactation 1 (before)	2.3 (1.7)	2.6 (2.1)	0.3 (1.9)	11.8 (6.2)
	Lactation 2 (after)	1.9 (2.4)	3.3 (1.5)	1.4 (1.8)	12.8 (4.9)

*Paired *t*-test: Posttreatment once daily milk production difference between treated (infected) and control quarters was significantly different from the pretreatment milk production difference in the povidone-iodine group ($P = 0.0007$).

to compare two treatments than one treatment and control. The techniques described herein are not intended for routine dry cow therapy, but are intended as a possible method for ceasing lactation of a *S. aureus*-infected quarter in midlactation, thereby decreasing the likelihood that the infected mammary quarter will be a reservoir for infection of other cattle. It should be recognized that the use of chlorhexidine or povidone-iodine for therapeutic cessation of lactation constitutes an extra-label use of these drugs. Presently, there are no approved products for therapeutic cessation of lactation. The Louisiana study found that secretion from mammary quarters treated with chlorhexidine might have antimicrobial residues (Delvotest, Gist-Brocades, Delft, Holland) for up to 35 d following infusion; however, no residues were detected in the untreated quarters following infusion (Boddie and Nickerson, 1993). The Delvotest is a microbial inhibition test and therefore does not give any indication of the actual level of chlorhexidine in milk after treatment. No data could be found concerning milk and slaughter withdrawal times for povidone-iodine when used in the manner described here. We withheld milk from the bulk tank for a minimum of 96 h following infusion because cows had been treated with flunixin meglumine. Due to the lack of data regarding meat and milk residues when chlorhexidine and povidone-iodine are used in the manner described here, it should be recognized that before these techniques can be adopted on commercial dairies further research needs to be performed to assess meat and milk residues.

If the primary objective is to eliminate the mammary quarter from lactation and thereby presumably lower the risk of herdmates acquiring new *S. aureus* IMI, then povidone-iodine appears to be the best of the two methods. Povidone-iodine in this study eliminated all treated mammary quarters from lactation permanently, whereas chlorhexidine only caused permanent cessation of lactation in the treated quarter in 29% of cases. Therefore, there is a risk of the treated quarter returning to function in the subsequent lactation and being a reservoir for infection of other cattle about 40% of the time when chlorhexidine is used. Additionally, there was no difference in total milk production between lactations one and two in either group, suggesting that even if the mammary quarter is permanently lost, there is no detriment to overall milk production in the subsequent lactation. Hence, therapeutic cessation of lactation with povidone-iodine may have future merit as a technique for eliminating *S. aureus* infected mammary quarters from lactation, thereby minimizing their ability to shed *S. aureus* and infect other cattle.

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