EFFICACY OF A *STAPHYLOCOCCUS AUREUS* BACTERIN IN REDUCING THE NEW INFECTION RATE AND SOMATIC CELL COUNT IN A COMMERCIAL DAIRY

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ABSTRACT

Use of a *Staphylococcus aureus* bacterin to prevent intramammary infections (IMI) in dairy heifers was evaluated. At 6 to 18 months of age, Holstein heifers were processed for vaccination and collection of mammary secretions. Fifty-three heifers were immunized with a commercial bacterin and 53 heifers served as unimmunized controls. The vaccine was a lysed culture of polyvalent *S. aureus* somatic antigens of 5 phage types in an aluminum hydroxide base. Two weeks after processing and at 6-month intervals until calving, vaccinates were processed for boosting. At 2-month intervals after trial initiation and through calving, mammary secretion samples were collected for bacteriological culture and somatic cell counts (SCC). Efficacy data showed that the percentage of heifers with *S. aureus* IMI at calving was lower in vaccinates (13.3%) compared with controls (34.0%); a reduction of 60.9%. The SCC in samples collected at calving from uninfected heifers for vaccinates and controls were 66,095 and 132,754/ml, and for infected heifers, SCC were 441,764 and 892,176/ml; reductions of approximately 50%. Likewise, average first lactation SCC were lower in vaccinates than controls (49,000 vs. 60,000/ml). The 305-day lactation milk yield for the first lactation demonstrated an 8.6% increase in vaccinates vs. controls (11,217 vs. 10,332 kg). In addition, the 305-day lactation kilograms of fat and protein were higher in vaccinates than controls (fat: 408.04 vs. 338.96 kg; protein: 329.77 vs. 315.23 kg). Evaluation of the number of days in milk for the first lactation demonstrated that vaccinates persisted 13 days longer than unvaccinated controls (349 vs. 336 days), and culling was reduced by one-third in vaccinates (16.9%: vaccinates, 24.5%: controls). Results demonstrated that administration of a commercial bacterin to breeding age and pregnant heifers reduced prevalence of *S. aureus* mastitis and SCC at calving, and increased first lactation performance.

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INTRODUCTION

Staphylococcus aureus mastitis continues to be a major challenge for the dairy industry because this disease is difficult to treat with antimicrobial drugs, especially during lactation. In some herds, *S. aureus* mastitis is prevalent in unbred and bred heifers, which serve as sources for infecting the milking herd. Such intramammary infections (IMI) in young dairy animals are associated with local inflammation, induration, and extremely high somatic cell counts (SCC), and have been found in heifers as early as 6 months of age (Boddie *et al*., 1987). Likewise, histological analyses have shown that *S. aureus* infections adversely affect the development of milk-producing tissues of heifers (Trinidad *et al*., 1990a).

Although intramammary therapy during gestation (Owens *et al*., 1994; Trinidad *et al*., 1990b) and during the immediate prepartum period (Oliver *et al*., 1992; Oliver *et al*., 2004) has been successful, the most efficient means of controlling mastitis is to prevent this disease in young dairy animals. Vaccination has been attempted to increase adult cows' immunity to *S. aureus* and to prevent establishment of these bacteria in the bovine mammary gland. Early vaccine formulations were shown to increase the spontaneous cure rates of *S. aureus* IMI in cows as well as to lessen the severity of infection but did not prevent new cases of mastitis (Adlam *et al*., 1981; Brock *et al.*, 1975). More recently, various toxoids and adjuvants have been incorporated into experimental pseudocapsular vaccine formulations, and have been shown to be effective in preventing new *S. aureus* IMI when administered to dairy heifers (Giraudo *et al*., 1997; Nickerson *et al*., 1999; Nordhaug *et al*., 1994; Sears *et al*., 1990). In view of these successes, the present study was designed to evaluate a commercial *S. aureus* bacterin when administered to Holstein heifers as a primary immunization at 6 to 18 months of age.

MATERIALS AND METHODS

One hundred six Holstein heifers from the James River Correctional Center dairy herd Goochland, VA, USA were used. This herd had a 9,979-kg rolling herd average milk production with an average SCC of ~200,000/ml. Previous microbiological culture of heifer mammary secretions indicated that approximately 35% of animals were infected with *S. aureus*.

At approximately 6 to 18 months of age, heifers were processed through a restraining chute to collect aseptic quarter mammary secretion samples for microbiological analyses following procedures outlined by the National Mastitis Council (Hogan *et al*., 1999). Fifty-three heifers were vaccinated with Lysigin® (Boehringer Ingelheim Vetmedica, Inc., St. Joseph, MO, USA) using a dose of 5 ml intramuscularly that was administered in the semimembranosus muscle of the rear leg, and the other 53 heifers served as unvaccinated controls. The vaccine was a lysed culture of polyvalent *S. aureus* somatic antigens representing 5 phage types in an aluminum hydroxide adjuvant base, including serotypes 5, 8, and 336, the most common *S. aureus* serotypes associated with clinical mastitis. Fourteen days after the initial processing, the vaccinated group was again processed through the chute and boosted with Lysigin®. All animals were maintained on pasture and rotated by age group through calving. At 6-month intervals after the initiation of the trial and through time of calving, the vaccinated group was again processed through the chute for boosting.

At 2-month intervals after the trial initiation and through calving, mammary secretion samples were collected for bacteriological culture and for the determination of electronic SCC (A/SN Foss, Hillerod, Denmark). Microbiological examination of quarter samples collected from bred heifers over gestation demonstrated that 19.8% of heifers (9.4% of quarters) were infected with *S. aureus*, 68.9% of heifers (34.3% of quarters) were infected with coagulase-negative staphylococci (CNS), 6.6% of heifers (2.3% of quarters) were infected with environmental streptococci, and 1% of heifers (0.3% of quarters) were infected with coliforms.

At time of calving, heifers were enrolled in the Dairy Herd Improvement Program (DHIA) and data were recorded for milk yield, percentages and actual pounds fat and protein, days in milk, and SCC. Data on vaccine efficacy were examined in terms of mean percentage

reduction in rate of new *S. aureus* or CNS IMI achieved among immunized heifers compared with the rate among unimmunized controls at the time of calving; differences between the percentage of heifers becoming infected among treatments was tested with the standard normal approximation (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Immunization with Lysigin® did not cause any adverse reactions at the injection site or systemically. Minimal swelling (<2.5 cm) was occasionally observed, which disappeared within 48 hours of administration. Vaccine efficacy data showed that the percentage of heifers with *S. aureus* IMI at freshening was lower in vaccinates (13.3%) compared with controls (34.0%); a reduction of 60.9% ($P \leq 0.01$). Likewise, an examination of health records showed that the percentage of heifers that were culled or died during the trial was reduced by approximately one-third by vaccination: 16.9% in vaccinates and 24.5% in controls ($P > 0.05$). The vaccinated group also experienced a slight, insignificant reduction in mastitis caused by CNS. At freshening, IMI with CNS were lower in vaccinates (64.2%) compared with controls (69.8%); a reduction of 8.1%.

Somatic cell counts in samples collected during first week of lactation irrespective of infection status were 45% lower in vaccinates compared with controls (287,317 vs. 522,345/ml). Somatic cell counts in samples collected during first week of lactation from uninfected heifers for vaccinates and controls were 66,095 and 132,754/ml, respectively; a 50.2% reduction; and for infected heifers, SCC were 441,764 and 892,176/ml, respectively; a 50.5% reduction. Somatic cell counts in samples collected during the prepartum period were highest for *S. aureus* ($6,730 \times 10^3$), followed by the environmental streptococci ($3,850 \times 10^3$), and CNS ($3,510 \times 10^3$).

An examination of the 305-day lactation milk yield for the 1st lactation of both vaccinated and unvaccinated control heifers demonstrated an approximate 8.6% increase in vaccinates vs. control (11,217 vs. 10,332 kg, respectively) or a difference of 886 kg. On a complete lactation basis, vaccinated animals produced 839 kg more milk than controls (12,537 vs. 11,698 kg, respectively); an increase of 7.3%.

The percentage of 305-day lactation fat was higher in vaccinates than controls (3.64 vs. 3.27%, respectively); however, the percentage of 305-day lactation protein was slightly higher in controls than vaccinates (3.06 vs. 2.95, respectively). Actual 305-day kilograms of both fat and protein were higher in vaccinates than controls (fat: 408 vs. 339 kg, respectively; protein: 330 vs. 315 kg, respectively). Likewise, on a complete lactation basis, actual kilograms of both fat and protein were higher in vaccinates than controls (fat: 460 vs. 393, respectively; protein: 370 vs. 353, respectively).

An examination of the number of days in milk for the first lactation demonstrated that vaccinates persisted 13 days longer than the unvaccinated controls (349 vs. 336 days). In addition, average first lactation SCC were 11,000 cells/ml lower in vaccinates compared with controls (49,000 vs. 60,000/ml.

CONCLUSIONS

Results of this investigation demonstrated that vaccinating dairy heifers according to the prescribed protocol with a commercial USDA licensed *S. aureus* bacterin, Lysigin®, reduced the number of new *S. aureus* IMI at time of calving by 60.9%, lowered the SCC by 50%, and decreased the culling rate by approximately one-third. In addition, overall milk yield, production of fat and protein, and number of days in milk were greater in vaccinated heifers compared with controls.

The decrease in frequency of new *S. aureus* IMI at calving (60.9%) in vaccinates using Holstein heifers is higher than the 44.7% reduction observed in a Louisiana trial using the same vaccine in Jersey heifers (Nickerson *et al*., 1999). In both trials, SCC at calving were reduced by approximately 50%. The 60.9% efficacy found in the present trial is also higher than the 40.2% efficacy observed by Giraudo *et al*. (1989), the 46% efficacy observed by Nordhaug *et al*. (1994), and the 52% efficacy observed by Sears *et al*. (1990). However, it is difficult to compare among the latter three trials as the vaccine formulations were all quite different.

The question becomes: Is it economically feasible to use this vaccination protocol on young dairy heifers? Based on an average of 1,864 more lb milk per vaccinated heifer, which translates to 18.64 hundredweights (cwt) of milk (1,864/100), at the current price of $25.00/cwt, an increased income of $466.00/heifer would be realized (18.64 cwt x $25.00/cwt = $466.00). If each heifer was vaccinated beginning at 6 months of age until calving, this would entail vaccinations at 1) 6 months, 2) a booster 2-weeks later, and subsequently at 3) 12 months, 4)18 months, and 5) 24 months, or a total of 5 immunizations through calving. At $1.50/dose, this cost would total $7.50, which when subtracted from the increased income from milk production, would yield a net income of $458.50 per heifer ($466.00 - $7.50). This figure does not include the costs of labor involved in the immunization process; however, it is evident that vaccination is well worth the cost of the vaccine. Not only does it reduce new infections in first calf heifers at parturition, it may also reduce the introduction of *S. aureus* to the milking herd.

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