Management Alternatives in Mastitis Control and Eradication Programs

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Herd management programs that are successful in eliminating contagious mastitis include dry cow therapy, segregation and selective culling. When infections involve *Streptococcus agalactiae*, lactation therapy is still successful although there has been an increase in the number of *Strep ag* isolates resistant to penicillin and other beta-lactum antibiotics. The major difficulties occur when *Staphylococcus aureus* is isolated as the primary pathogen in the herd. The primary source of these infections are infected glands and unless these reservoirs are eliminated, new infections will continue to occur. Uninfected cows are mainly exposed during milking but dry cows and prepartum heifers are still at risk when contagious pathogens are present in the lactating herd. Although the method of spread is unknown in nonlactating animals, heifers can become infected before calving with the same strains of organisms as found in the lactating cows.[1] Once *Staph aureus* infections are eliminated from the lactating animals, the number of infected heifers at calving decreases and often disappears. This is most apparent in herds where *Staph aureus* has been rapidly eliminated from lactating cows where there is a concurrent rapid decrease in new infections in the heifers at calving. The links speculated as the sources of exposure include insect vectors,[2] but the reservoir appears to be the adult lactating animal.[1] Because of the spread to young uninfected animals as well as other cows, there is an incentive to try to eliminate these infections from lactating cows. Segregation is an important tool in reducing the risk of exposure at milking, but it does not address other sources of spread. However, many farms cannot create an additional group to segregate infected cows because the group is not the correct size or does not fit well with feeding groups. Likewise, most producers are unwilling to cull infected animals that are producing well and find that the poor response to antibiotic therapy in both lactating and dry cows is frustrating when trying to eliminate *Staph aureus* from their herds. Since *Staph aureus* infection can occur anytime during lactation, the longer the lactation and the older the animals, the greater the risk of becoming infected. Thus, herds that have younger cows and a high turnover rate often have a lower prevalence of *Staph aureus* infected cows, while well established herds with good longevity have greater exposure and accumulate more infections. It is these herds that are trying to retain cows and reach mature production that are often fighting problems with staphylococcal infections. However, no herd is exempt from *Staph aureus,* even with high turnover, especially if they are purchasing animals.

Antibiotic Therapy

Antibiotic treatment during the dry period is still the most effective management practice that we have to eliminate *Staph aureus* infections. However, even using dry cow therapy, the elimination of *Staph aureus* seldom exceeds 50% of infections. Treatment during lactation for *Staph aureus* is often unrewarding because it seldom eliminates the infection.[4] Antibiotics may lower the number of bacteria and reduce the clinical signs of mastitis, but cows remain infected and continue to have a high somatic cell counts even when the clinical signs are absent. When clinical cases are monitored, many of the clinical cases are observed in the same cows. Thus, once the cow has a clinical case she is more likely to have additional episodes. Milk withdrawal and culling of infected cows are major economic losses on these farms.[5] Traditional use of intramammary antibiotics during lactation has met with limited success with often less than 10% cures.[4] In a recent trial measuring efficacy of pirlimycin using intramuscular, intramammary and combination of intramuscular and intramammary treatment, cure rates were only 3.7% for IM, 0% for intramammary and 7.4% for the combination therapy.[5] However, the same researchers were able achieve a much higher rate of cure (48.8%) using extended therapy of 3 sequential courses of pirlimycin intramammary over 8 days.[6] The lack of success with antibiotic therapy has been attributed to inaccessibility, the lack of susceptibility of organisms, limited duration of exposure to antibiotics, and poor immune function. Thus, the response to intramammary antibiotic treatment

is better when the treatment length is extended and the milk SCC is less than 1,000,000 cells/ml.[7]

Role of Vaccination for Staph aureus

Research on immunizing animals against *Staph aureus* has attempted to identify the best antigens to induce antibody production to prevent new infections. Antigens that have been studied include Protein A, a cell wall component of *Staph aureus* which interferes with the Fc portion of IgG so that antibody opsonization is inhibited and the organism is not recognized by phagocytic cells and prevents phagocytosis and killing by neutrophils.[5] Fibronectin, another important virulence factor of *Staph aureus,* has been used to produce antibody against these surface adhesion factors.[5] However, some of the most successful immune responses subsequent to vaccination with staphylococcal vaccines occurred when highly encapsulated strains of *Staph aureus* were used which resulted in a reduction of new infections in heifers after calving.[9,10] These vaccines have been effective when given to heifers before calving to prevent new infections after challenge in early lactation.[10] Vaccines made using highly encapsulated *Staph aureus* strains and extractions of exopolysaccharides were effective in reducing new *Staph aureus* infections at calving from 18.8% in controls to 6.0% in vaccinates, and this protective effect was maintained for at least 6 months.[5] The study also showed a reduction of clinical signs of mastitis. All of the studies have been aimed at preventing new infections or clinical cases but none of the studies have demonstrated an improvement in eliminating previously existing infections.

Can immune modulation enhance Staph aureus *cures?*

Since the somatic cell count at time of therapy affects bacterial clearance, it stands to reason that enhancing the immune response could aid in the clearance of bacteria. Although these vaccine preparations have been successful in preventing new infections, vaccination alone has not been successful in eliminating existing infections.[8] Most bacterins do not produce long lasting antibody levels, but if timed with antibiotic therapy, immune modulation might optimize bacterial clearance.

Traditionally, therapy during lactation has not been considered an economical approach to eliminate *Staph aureus* mastitis and vaccination programs have been aimed at prevention. In a more recent study, we used a vaccine containing both autogenous and capsular antigens to immunize *Staph aureus* infected cows and amplify the cow's immune system against *Staph aureus,* thereby improving the effectiveness of antibiotic therapy. Immune modulation and antibiotic therapy was used in a 48-cow herd on 19 quarters in 10 cows infected with *Staph aureus*. Cows were immunized 2 and 14 days before starting antibiotic therapy. Extended therapy was used treating each infected quarter with 3 sequential courses of pirlimycin over an 8 day period. A third vaccination was administered during treatment at 7 days into the treatment. All but 3 quarters responded to the antibiotic therapy and all *Staph aureus* was eliminated by 3 months. The herd bulk tank somatic cell count decreased from 492,000 cells/ml at the time the trial was initiated to 187,000 cells/ml after 3 months and 84,000 one year later. For this herd a calculated cost of $2656 for identification and treatment of *Staph aureus* infected cows provided a projected saving of $5376 to move the DHIA-SCC from a LS 5.3 to LS 2.8 (Table 1). It would only require a 40% cure rate for the saving to equal the expense (cow cure 80% x 49% saving by LS/vaccination-treatment cost) as calculated from Table 1. However, this does not factor in additional gains by reducing future losses that would have occurred if *Staph aureus* had remained in the herd.

Table 1. Economic impact of *Staphylococcus aureus* elimination program

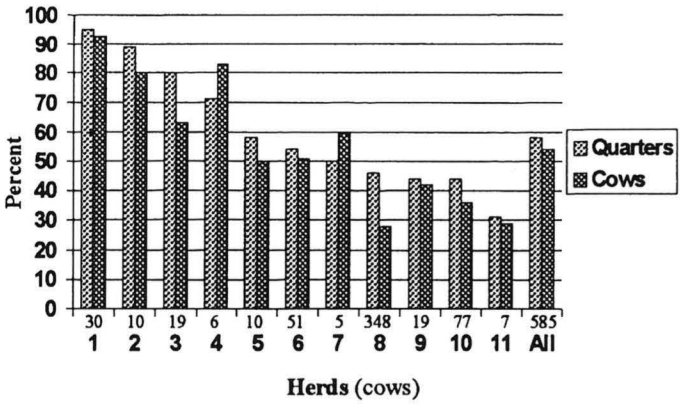
Cost of Program		Herd
Herd culture to ID infected cows	50 cows @ $3.00 twice	$300.[a]
Lactation therapy	24 tubes @ $3.00	792
Vaccination	16 *Staph aureus* cows	100
Dry cow therapy	5 cows (lact + dry therapy)	410
Milk loss for residue withdrawal	12.00 cwt for 80 lb/day	1054
Cull	3 cows @ $600 loss/animal	1800.[a]
Total		$2656
Income Savings		
Milk gain based on SCC-LS	LS 5.3 to 2.8	$5376
Milk gain based on ME for *Staph aureus*	Infected vs herdmates	$6846
Reduced culling for *Staph aureus*	6 cows @ $600	$3600.[b]

[a] Cost varies with size of herd and animals removed for low economic value

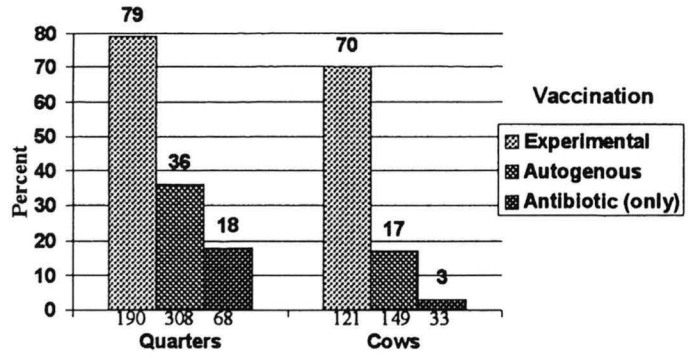
[b] Animals removed in 1995 with *Staph aureus* infection for low economic value

Efficacy

In an additional 10 herds tested, the quarter cure rate (Graph 1) following antibiotic therapy ranged from



Graph 1. The distribution (11 herds) of the rate of elimination of *S. aureus* from infected quarters after immune modulation with staphylococcal antigens and six intramammary treatments (3 sequential courses) of pirlimycin hydrochloride.



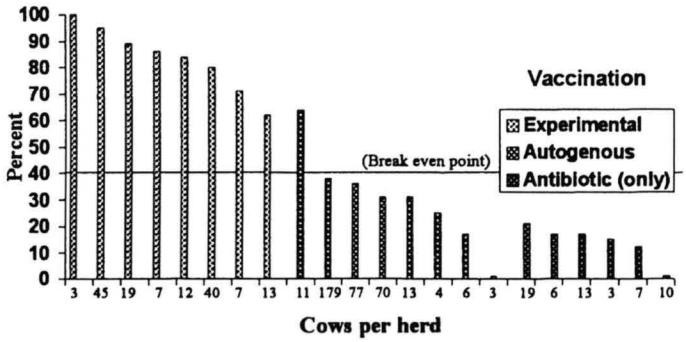
Graph 2. The rate of elimination of *S. aureus* following six treatments (3 sequential courses) of pirlimycin hydrochloride after immune modulation with a combination staphylococcal bacterin (experimental), autoenous staphylococcal bacterin or antibiotic treatment only.

29% (7 cows) to 95% (30 cows) with a mean herd average cure of 58% for quarters and 54% of cows. There were two groups of cows (14 cows) that received vaccination without antibiotic therapy, in which none of the quarters cleared the *Staph aureus* infection. These cows were later included into a treatment group and treated with intramammary antibiotic with the same success rate as others in the vaccination-treatment group. There was no difference (P<.001) between cow and quarter rate of cures, although some cows with multiple infected quarters had some quarters clear while other remained infected. Antibiotic treatment was less likely to eliminate all quarter infections in cows when more than 2 quarters were infected. No differences were noted in cows with 1 or 2 infected quarters. Animals in the combination bacterin group responded better to antibiotic therapy, 79% of quarters and 70% of cows, than did animals in the autogenous bacterin group, 36% of quarters 17% of cows (Graph 2). Immune modulation was beneficial since vaccination with both the autogenous or the combination bacterin increased the rate of cures compared to treatment alone.

Discussion

The use of staphylococcal vaccination has been successful in preventing new intramammary infections[10,11] and reducing the number of clinical cases,[12] however use of a bacterin in infected cows has not affected the persistence of subclinical *Staph aureus* infections. In these studies all vaccinations enhanced the elimination of *Staph aureus* from infected quarters, although there was a difference between the types of antigens (Graph 2). Herd size and number of infected cows and quarters did not affect the overall cure rate as measured for all cows and compared to the mean cure rate of each herd. The combination bacterin was more effective in eliminating existing infections as measured by quarters and cows. Using cost/benefit analysis Break Even Point (BEP) of 40% based on SCC-LS savings (Table 1), one third (3/11) of the herds (Graph 1) would not have financially benefited from the vaccination-treatment protocol. Only 1 herd exceeded the BEP in the autogenous bacterin group while cows in all herds using the combination bacterin exceeded the BEP (Graph 3).

It is both possible and economically sound (Table 1) to use lactating therapy combined with immune enhancement to develop a mastitis control strategy to eliminate *Staph aureus* from lactating dairy cows. Although selective removal of low value cows and utilizing treatment in the dry period can be an important part of any mastitis control plan, it is not necessary to



Graph 3. Distribution of the rate of elimination of *S. aureus* (by herds) following 3 sequential courses of pirlimycin hydrochloride after immune modulation with a combination staphylococcal bacterin (experimental), autoenous staphylococcal bacterin or antibiotic treatment only. *Break even point* indicates the cure rate level (40%) needed for the economic outcome to equal vaccination and treatment costs.

use these management practices as the sole means of eliminating *Staph aureus* in the herd.

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