

Staphylococcus aureus Mastitis

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Introduction

Staphylococcus aureus is an important bacterial cause of contagious mastitis on dairy farms worldwide. More importantly, it is often at the root of chronically high somatic cell counts, recurrent clinical mastitis, and damaged mammary gland tissue. It is considered to be a contagious udder pathogen that spreads within and between cows during milking. Because it is often subclinical (milk looks normal but with a potentially high somatic cell count), infected animals pose a risk of infection to herd mates during each milking. Control is heavily dependent on prevention of new infections through the use of proper milking procedures and improved milking hygiene to prevent exposure and spread of mastitis. Milking system maintenance, housing and bedding management, and fly control are also essential elements for prevention of new mastitis cases. The best method to diagnose and treat *Staph. aureus* mastitis is through identification of quarters producing milk with a high somatic cell count followed by bacterial culture and determination of the best antibiotic to kill the causative bacteria. To control the damage caused by this organism, it is critical to identify *Staph. aureus* infected cows quickly, then segregate and milk these cows last if possible. A decision must then be made whether to treat the individual case with antibiotics, cull the cow, or stop saving milk from the infected quarter or quarters. Unfortunately, research indicates the cure rate for *Staph. aureus* infected cows after treatment ranges from 4% to 92%, with overall success averaging a dismal 20% to 30%.

Transmission

The bacteria survive in the mammary gland, teat canals, and teat lesions of infected cows. They thrive in scabby or injured teat ends caused by overmilking, chapping, frostbite, biting flies, or improper pulsation or vacuum settings. The infection is spread during milking when *Staph. aureus* contaminated milk from an infected gland comes in contact with an uninfected gland and the bacteria enter the teat canal. This spread may occur through contaminated udder wash rags, common towels, teat cup liners, milkers' hands, flies, and cross-suckling. Improperly functioning equipment, especially irregular vacuum fluctuations, can force bacteria up into the teat canal and begin a new infection.

Prevention

As with all types of mastitis, the most important and economically feasible approach to control of *Staph. aureus* mastitis is prevention of the disease. Given the difficulties and relatively low likelihood of treatment success with *Staph. aureus* mastitis, dairy producers dealing with this type of mastitis should re-examine management practices to focus on prevention of future infections.

Moreover, if proper preventive measures are not in place, therapy will not be as effective in reducing the overall prevalence and impact of infections. The 10-point program published by the National Mastitis Council in 2001 covers effective practices for management of udder health to control all mastitis pathogens (<http://www.nmconline.org/docs/NMCchecklistInt.pdf>). Prevention of contagious mastitis is based on eliminating conditions that expose the teat end of healthy cows to bacteria from infected cows, primarily during milking, thereby reducing the possibility of spread. A video is available at <http://www.youtube.com/ukagriculture#p/u/49/rsIsN->

hEUqz0 illustrating correct practices in the parlor. The UK College of Agriculture video *Milking Procedures for Maximum Milk Quality* (at <http://www.youtube.com/watch?v=mBgon39usbQ>) is another excellent resource of information on protecting healthy teats from unwanted infection.

In the parlor, certain practices are of particular importance including the following:

- Wear latex or nitrile gloves during milking and change, rinse off, or sanitize them when they become dirty or after stripping an infected cow.
- Remove dirt, debris, and manure from the teats without water. The goal should be to remove water from all milking procedures.
- Properly use pre- and post-dips to ensure adequate coverage (at least $\frac{3}{4}$ of the teat) and contact time (20-30 seconds). Numerous studies have shown proper post-dipping with an effective germicide will reduce new infections by contagious pathogens by 50%.
- Always use individual, dry paper, or cloth towels. Never use wet cloth towels shared between cows.
- Milk clean, dry teats with particular emphasis on removing all dirt and debris from the teat end to minimize chances of introduction of bacteria into the teat.
- Examine teat ends for chapping, scabs, and other lesions. Use dips with emollients to keep teat ends supple and healthy.
- Properly attach, position, and remove units, making sure they are removed in a timely manner. Quickly correct liner slips and squawking.
- Milk cows with mastitis last in the milking order to minimize the chances of cross-contamination.
- Use dry cow therapy for all cows in the dry period; it is the most effective method of eliminating existing infections and preventing new infections during that time.

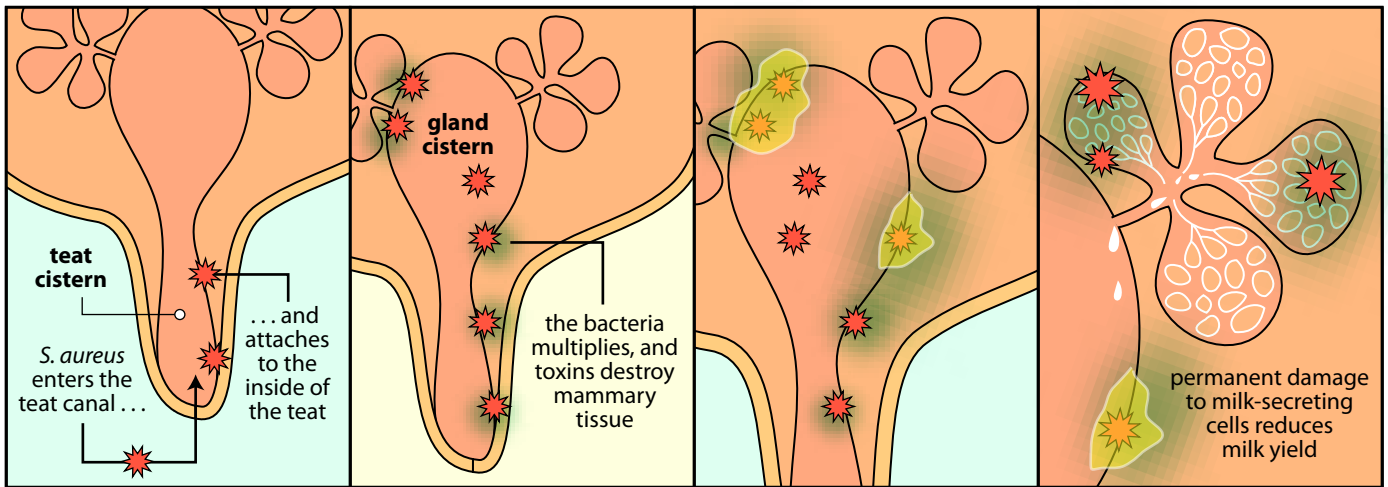


Figure 1. How *S. aureus* infects a cow's udder.

- Keep milking equipment in top-notch condition. Regular preventive maintenance and system evaluations are essential to prevent a backflow of milk against the teat end, which can actually propel bacteria up into the teat canal and teat cistern during milking.
- If purchasing heifers or cows, segregate them and milk them last until milk cultures can be performed. Do not buy someone else's problem and introduce it into your herd! Examine the Dairy Herd Improvement Association Somatic Cell Count on each cow before purchase.
- Control flies. Biting flies traumatize teat ends and carry bacteria between cows. Eliminate fly breeding sites, and use insecticides to lower fly numbers on the cows and heifers.

In addition, when only a small percentage of the herd is positive for *Staph. aureus*, producers should carefully consider culling infected cows quickly to avoid contamination of the rest of the herd.

Finally, although bulk tank cultures will not predict prevalence of mastitis in the herd, culturing the bulk tank monthly can identify the presence of *Staph. aureus* mastitis. Remember, however, that bulk tank cultures are not a substitute for quarter milk samples in determining herd prevalence.

Infection by the *Staph. aureus* Organism

The infection process occurs as follows:

- Once the bacteria enter the teat canal, the first infection stage is adhesion. The bacteria attach themselves by releasing “sticky” proteins that glue themselves to cells inside the teat.
- Once attached, the bacteria can begin to multiply without being eliminated during milking. The *Staph. aureus* bacteria produce a toxin that destroys cells and damages milk-producing tissue. The bacteria begin their assault by damaging the tissues lining the teat and gland cisterns, which leads to formation of scar tissue in those areas.
- These bacteria are very highly adapted to survival inside the mammary gland. The *Staph. aureus* bacteria are able to form a “biofilm”—a slime cover that shields them from certain types of protective cells of the immune system and antibiotics. They also have the ability to live inside the white blood cells of cows, which also protects them from the expected effect of antibiotic therapy.
- The bacteria continue to move up into the milk-secreting cells to establish deep-seated pockets of infection. Once there, they permanently damage the alveolar and ductal cells, reducing milk yield. The cow's immune system sends cells to form a wall (called an “abscess”) around the infected area of the gland.

This wall slows or stops the bacteria from further spreading, although the organisms continue to survive and remain protected from antibiotics inside the abscess. Abscesses can become quite large and are detectable as lumps that can be felt in the udder.

Diagnosis

Diagnosis of *Staph. aureus* infections helps in developing preventive strategies and in determining where deficiencies in mastitis control procedures may occur. Identification is based on bacterial culture of a properly collected milk sample (See UK Cooperative Extension publication *Collection and Preparation of Milk Samples for Microbiological Culturing* [ID-180].) Bulk tank cultures can also be used to alert the producer to the presence of the organism and the need to examine individual problem cows. The best method to detect *Staph. aureus* mastitis is to (1) identify all high SCC cows (more than 200,000 cells/ml), (2) perform the California Mastitis Test (CMT) on those cows to determine which quarter or quarters are affected, and (3) culture the milk from those quarters. It is extremely important to identify infections early in order to prevent spread and to increase the chance of cure. An “antibiotic susceptibility” on the bacteria may be requested (for an additional fee) from the laboratory to determine which antibiotics should work best.

On-farm culture systems are available to identify several mastitis pathogens including *Staph. aureus*. Be aware that in order for these systems to be successful, a clean and well-organized laboratory space with a trained person to perform the tests is necessary. An initial investment in equipment is also necessary such as culture plates, an incubator, and training that may be difficult to justify economically for small farms.

Treatment

Treatment choices for clinical (abnormal milk) and subclinical (normal looking milk but high SCC) mastitis involve a wide variety of antibiotics. Because one strain of *Staph. aureus* usually predominates in a herd, submission of milk samples for culture and antibiotic susceptibility are necessary to generate “herd level knowledge” of the bacterial problems present on a particular farm. A susceptibility panel tests many different antibiotics to see which ones are most likely effective against the bacteria. Many *Staph. aureus* strains are found to be penicillin resistant on susceptibility panels, which means their strains produce beta lactamase, an enzyme that makes penicillin and all other similarly acting drugs worthless in the war against mastitis. It is estimated that 30-70% of *Staph. aureus* strains are penicillin resistant in the United States. Interestingly, penicillin-resistant strains are far less likely to respond to any type of antibiotic, so the cure rate for all penicillin-resistant *Staph. aureus* is considered very low and should be an important factor in selecting cows to cull instead of treat.

To improve treatment response, numerous trials have been conducted studying antibiotic routes of administration, durations of therapy, different combinations of drugs, and alternative therapies. Results of these studies indicate the response to treatment of *Staph. aureus* is often poor, but one promising possibility is extended therapy. Research has confirmed that longer treatment regimens (five to eight days) are associated with a higher probability of cure caused by Gram (+) pathogens. Only one product on the market (Pirsue®) is labeled for and demonstrated effective with

extended therapy against *Staph. aureus*. In a large multinational study published by Deluyker et al. (2005), the cure rate for subclinical *Staph. aureus* mastitis was 6% for those with no treatment, 56% for a two-day Pirlimycin (Pirsue®) treatment, and 86% for eight days of Pirlimycin (Pirsue®) therapy. This product is prescription only, so a valid veterinary/client/patient relationship must exist to obtain this medication. However, extended therapy is not “extra-label”—in other words, a producer can follow the label directions on the box instead of the veterinarian needing to write special or alternate directions for use.

The benefits of extended therapy include a higher proportion of cure, decreased SCC, less risk of spread, and improved milk marketability.

These benefits must be weighed against the drawbacks of the price of the antibiotic, loss of milk due to long withdrawal times, increased risk of residues in meat and milk, and potential to cause more mastitis through repeated infusions in the teat canal, especially with *E. coli*, *Klebsiella*, and yeast.

Unfortunately the cost-benefit ratio for most extended therapy regimens is poor, but it is an option for extremely high producing or valuable animals or in situations where the risk of spread is very high.

Alternative and/or complementary therapies are currently being explored due to the limited effectiveness of antibiotics in the treatment of *Staph. aureus* mastitis. Bacteriocins (such as nisin), immunostimulants (such as ginseng) and immunomodulators (such as beta-1,3-glucan) have not shown consistent positive results and require more study before recommendations can be made for their use.

Dry cow therapy is considered more cost effective in eliminating *Staph. aureus* infections than lactating treatment but not if the infections have already become chronic by the end of lactation. Acute (beginning or first time) *Staph. aureus* infections may develop any time during lactation and cause an increase in SCC, but often the clinical signs of udder swelling, hardness, and changes in the milk do not show up until calving or early in the next lactation. Treating all four

quarters with a commercially available dry cow therapy attacks the bacteria with a higher concentration of antibiotic over an extended period of time, increasing the chance of bacterial cure. However, with increasing pressure to deliver milk with a low bulk tank SCC, it may not be possible to wait until dry-off to treat subclinical mastitis.

There is one commercially available vaccine against mastitis caused by *Staph. aureus*, the Lysigin vaccine (Boehringer Ingelheim Inc.), which contains a lysed culture of five different strains of the bacteria. It is generally accepted that this vaccine has limited ability to prevent new infections. However, several small studies do support the ability of the vaccine to help cure mastitis. In general, progress is being made in the development and use of *Staph. aureus* vaccines, but the effectiveness varies widely depending on the herd. Research is ongoing in this area.

It is important to bear in mind that treatment decisions regarding *Staph. aureus*-infected cows go beyond the individual infected cow. Successful treatment or culling of a *Staph. aureus*-infected cow results in fewer new mastitis cases, less milk thrown away due to antibiotic therapy, lower somatic cell counts in the bulk tank and less milk production loss due to damaged glandular tissue. To definitively determine if a cow is cured of the infection, a milk sample from the affected quarter should be taken 21 days after the last treatment given and submitted for culture. In addition, the producer must monitor the SCC of the individual cow, as it should be declining over the following several weeks to months if the pathogens have been eliminated from the gland.

Control

Once *Staph. aureus*-infected cows are identified, segregation (milking *Staph. aureus* cows separately and last or with a separate milking unit) prevents the spread of contagious pathogens and will reduce the SCC in the bulk tank if the milk is discarded. Deciding who to treat vs. who to cull is the next important step. Although it is not always practical to cull all positive *Staph. aureus* cows, those with three or more cases in the same

quarter in the same lactation or whose milk was withheld a month or more during one lactation should be strong candidates for culling. When only a small percentage of the herd is positive for *Staph. aureus*, producers should carefully consider culling infected cows quickly to avoid contamination of the rest of the herd.

Certain cow factors that reduce the probability of a cure also need to be considered in the decision-making process. They include:

- **Increasing age of cow.** The higher parity, or higher number of times she has calved, is associated with lower chance of cure. Older cows are more likely to become infected and develop clinical *Staph. aureus* mastitis than younger herd mates. Cure rates are lower due to a much larger mammary gland and therefore a much larger volume of tissue for an antibiotic to penetrate and clear of infection.
- **High somatic cell count.** The cure rate is much lower if the somatic cell count is very high (above 1,000,000 cells/ml) by the time treatment is started.
- **Long duration of infection.** The longer the mastitis process progresses before treatment, the lower the chance of cure. One study indicated a 70%

cure rate in quarters treated within two weeks of infection vs. a 35% cure rate when treated after four weeks of infection.

- **High bacterial colony count.** A higher colony-forming unit count in the milk has been associated with a decreased chance of cure. This count is often reported on milk culture results.
- **More than one quarter infected.** The higher the number of quarters infected, the lower the chance to cure the cow. If all of the infected quarters are not cured, there is a good chance of infection spreading within the same cow to non-infected quarters or re-infection.
- **Infection of the hind quarters.** Hind quarters consistently are less likely to be cured than front quarters, which could be a consequence of the larger mammary gland structure and difficulty penetrating all areas with sufficient blood levels of antibiotic.

A study using a mathematical prediction of cure based on these factors found that the probability of cure for an older cow treated at 150 days in milk, infected in a hind quarter with a SCC of 2,000,000 cells/ml was approximately 1%, but a heifer infected in a front quarter at 220 days in milk with a SCC of 500,000 cells/ml had a 61% probability of cure.

First Lactation Cows

New infections in first lactation cows, either detected at calving or in early lactation, are commonly due to *Staph. aureus* organisms contracted during pregnancy. One option available is to treat heifers for mastitis before they calve. Administration to pregnant heifers of either dry cow therapy at approximately 60 days before calving or lactating cow therapy approximately 14 days prior to calving has been evaluated in several studies and found to be very effective in curing *Staph. aureus* mastitis. It is important to remember to check the milk for antibiotic residues before saving to the bulk tank. If left untreated, these heifers may calve with only three functional glands, will produce less milk during lactation, and will serve as reservoirs for infecting other cows in the herd.

In summary, *Staphylococcus aureus* is the most significant mastitis problem for Kentucky dairy farms. It is often the cause of chronically high somatic cell counts, recurrent clinical mastitis, and damaged mammary gland tissue. Awareness of how these bacteria survive and spread is essential to the diagnosis, control, prevention, and treatment of this type of contagious mastitis.