Bovine Mastitis

R. W. BROWN, JR.

MASTITIS means inflammation of the udder. It results principally from infection with micro-organisms. Many kinds of bacteria and some yeasts can produce mastitis. The streptococci (mainly *Streptococcus agalactiae*, *S. dysgalactiae*, and *S. uberis*) and the staphylococci (*Micrococcus pyogenes*) are the chief causative agents, but mastitis due to the bacteria *Escherichia coli*, *Aerobacter aerogenes*, and *Pseudomonas aeruginosa* has been occurring with greater frequency.

Other organisms, such as *Pasteurella multocida*, yeasts, and acid-fast bacilli, also have caused outbreaks of mastitis.

Air inflation of the udder will cure milk fever, but the danger of mastitis is so great that the practice has been abandoned except in dire emergency. It should be done with great care and strict antisepsis.

The procedure preferred by veterinarians is the intravenous injection of calcium gluconate in a 20-percent solution. Because acetonemia, or a lack of sugar in the blood, often accompanies milk fever, dextrose is added to the calcium solution. Calcium injections should be made slowly to avoid heart block, which is dangerous. Immediately after treatment the cow brightens up and usually makes a good recovery in 1 to 2 hours.

Relapsing cases may need one or more additional treatments. The cause of relapses has yet to be solved. Some authorities believe the addition of phosphates and magnesium to the calcium solution prevents relapses. When treatments fail, very likely the diagnosis was wrong or complications developed.

W. J. Gibbons is professor of medicine and infectious diseases in the Alabama Polytechnic Institute, in which he formerly was professor of large-animal surgery and medicine. For more than 20 years he was an instructor and professor in the New York State Veterinary College.

roid had been active to maintain calcium due to low intake.

They proposed the following formula for use during the dry period (in pounds): Ground barley, 800; rolled barley, 600; wheat bran, 500; cottonseed meal, 100; monosodium phosphate, 40; and salt, 10. Each cow should receive 8 pounds a day for 6 weeks before freshening plus 8 pounds of oat hay or poor hay.

In several herds where the incidence of milk fever was very high, feeding of the low-calcium diet reduced the number of cases from 30 to 3 percent. Production was not reduced noticeably.

Research conducted by J. W. Hibbs and H. D. Pounden, of the Ohio Agricultural Experiment Station, showed that the addition of vitamin D to the diet of the cow 5 days before calving reduces the incidence of milk fever.

The cow down with milk fever should be kept up on her sternum and not allowed to get out flat. Pneumonia caused by bloating and inhalation can be prevented by keeping the cow upright. The cow should be placed in a well-bedded stall to avoid injury. If she is in the pasture, she should be watched so that she does not roll or struggle into ditches or over embankments.
which have involved a large proportion of the cows in different herds. Another organism that usually causes sporadic cases, particularly in the dry cows rather than in lactating cows, is *Corynebacterium pyogenes*.

The udder also can become infected with bacteria that cause tuberculosis, brucellosis, and scarlet fever or streptococccis sore throat in man. Most of the varieties of bacteria found in mastitis, however, are harmless to the consumer. When milk is pasteurized properly, practically all danger is eliminated.

The bacteria that cause mastitis are usually carried from diseased cows to the teats of healthy cows on the hands of milkers or in the teat cups of milking machines during milking. Bacteria also can be spread by flies or by contact with contaminated bedding or floors.

Injury to the teat opening and teat canal and the improper use of teat tubes and dilators also are responsible for some udder infections.

The teat canal is of considerable importance in preventing infection and should be protected from injury as much as possible. Once the bacteria enter the opening in the teat, they may pass up the teat canal and establish themselves in the milk cistern or lower part of the quarter. From that point they spread to other parts of the gland.

**Mastitis exists in two forms—acute and chronic.**

Acute mastitis is readily detectable and is the form most familiar to the cattle owner. The affected quarter is hot, tense, hard, and tender. Milk secretion is largely or entirely suspended. The milk may be watery, straw-colored, or blood-tinged and may contain few or many clots. A general systemic disturbance, such as depression, fever, and loss of appetite, may be present. In acute mastitis, the organisms have invaded and inflamed much of the involved quarter.

Chronic mastitis is not readily recognized. That is because a general balance exists between the infecting organisms and the udder, with the result that few observable symptoms develop, although damage to the secretory tissue does occur.

Inflammation like that of the acute form also develops in chronic infections of the udder, except that it usually involves only very small areas of secretory tissue at any one time. Consequently the gland is not swollen and the milk appears normal, but the inflammation changes the composition of the milk. The milk does not contain the usual amounts of butterfat or milk sugar, but the number of leucocytes, the salt content, and the products resulting from inflammation and bacterial activity increase. Even those changes will not be found if the areas of inflammation involved are microscopic—yet the gland is infected and may be a constant source of infection to other cows.

Sometimes during a chronic infection, flareups occur. They may develop into acute mastitis or they may be milder and cause little or no swelling of the gland, but will change the milk so that it has flakes or clots and a watery or unusual appearance.

The milder symptoms are often called subacute mastitis and may disappear after several milkings, although the quarter remains infected.

As a result of the inflammation, the cells that secrete milk become inactive and may be replaced by nonsecreting fibrous or scar tissue.

When large areas of secretory tissue are destroyed, as in acute mastitis, the quarter becomes atrophied and hard. The changes are gradual in chronic mastitis. The hard areas, circumscribed or diffuse, usually are formed first near the milk cistern. The quarter gradually loses its soft, pliable quality. In advanced cases it becomes hardened throughout, and the secretory tissue is lost almost entirely.

The change in the character of the udder tissue causes a drop in milk production and shortened lactation periods. How long it takes for the change to occur in chronically infected quar-
Bovine Mastitis

Mastitis varies according to the virulence of the invading bacteria, the cow's natural resistance, and the number of acute or subacute attacks. Sometimes the animal passes through several lactation periods before the disease manifests itself, but many cows become useless in a short time.

The control of mastitis in any herd in which mastitis has become a problem is best attained by adopting a control program that includes an accurate diagnosis, adequate sanitary and management practices, proper treatment, and close cooperation between the dairyman and veterinarian.

The importance of management and veterinary service in the control of *Streptococcus agalactiae* mastitis was shown in a study conducted by the New York State Mastitis Control Program. In herds that had good management and adequate veterinary service, 71 percent made good progress in controlling mastitis, but in herds with poor management and inadequate veterinary service, only 19 percent made good progress.

Early detection and treatment of infected udders are necessary if one is to control the spread of infection. Acute attacks are diagnosed readily by clinical symptoms, but the chronic form presents some difficulty.

A combination of cultural and microscopic examination of quarter samples of milk is the best way to diagnose chronic udder infections. They are laboratory procedures that require milk samples drawn into sterile tubes or vials and trained persons to run them. All milk samples must be obtained as aseptically as possible. That means that the organisms that occur outside the udder on the skin and in the manure, dust, or bedding must be kept out of the sterile tube as the milk is withdrawn from the teat. Therefore, before the milk samples are obtained, the udder and teats should be washed and the teat openings thoroughly cleaned with a piece of cotton soaked with alcohol or some other nonirritating disinfectant. Any conditions that favor the raising of dust in the barn at the time of sampling should be prevented.

Simpler tests can be used on the farm. They depend on the physical and chemical changes in milk produced by mastitis. Anybody who uses them should understand that abnormal changes do not appear regularly in the milk of all cows with chronic mastitis and that the type of organism infecting the udder cannot be determined. A positive test in most instances indicates an infected quarter. But a negative test does not indicate that the quarter is not infected.

The simplest test uses the strip cup. Several streams of milk are drawn from a quarter into a cup covered by a fine-mesh wire screen or into a pan with black plastic or metal plates. The appearance of clots and flakes or watery or off-colored milk usually is evidence of mastitis. The test is limited because only infected udders that show gross changes in the milk can be detected. The strip cup should be used before each milking or at least once a day.

The second test is the bromthymolblue test. It is carried out by adding specific amounts of milk and dye solution in a test tube or by drawing a small amount of milk onto blotters impregnated with dye solution. Blotters and kits that contain test tubes, dye solution, and directions possibly may be purchased from farmers' cooperatives, feedstores, drugstores, or mail-order companies that sell farm equipment. The color resulting from the mixture of milk and dye depends on the degree of acidity or alkalinity of the milk. Milk from healthy quarters is slightly acid and gives a yellowish-green shade. In exceptional cases, a bright yellow or acid reaction may be observed. Milk from quarters affected with mastitis is predominantly green, because the milk is more alkaline. The more alkaline the milk, the darker the shade of green becomes.
This test discloses a somewhat larger number of diseased animals at any one time than the strip cup, but it should be used primarily to determine the relative amount of mastitis in a herd. The test, under most circumstances, will detect only about 33 to 50 percent of the infected quarters.

Another method for determining abnormal milk is the modified Whiteside test. It is simple and is more accurate than the other tests mentioned. It is used for individual cows. On an experimental basis it has been found useful for testing composite milk samples at a creamery to determine the herds from which mastitis milk is being delivered. To perform the test, 2 drops of a 4-percent solution of sodium hydroxide are added to 5 drops of fresh milk on a glass plate. If the milk has been refrigerated, only one drop of sodium hydroxide is used. The mixture is stirred with a glass rod for 20 seconds and then examined. Normal milk shows little or no change. Abnormal milk shows varying changes from a slight precipitate to a thick, sticky mass.

Neither the bromthymol-blue nor Whiteside tests should be used during the first several weeks of lactation or when the cow is almost dry, because false-positive reactions may occur.

Various management practices help control mastitis in a herd. Milking procedures and injury to the teats and udder have received the greatest attention as predisposing causes of mastitis, and most control programs emphasize measures to control them. Because the act of milking provides a constant source of contact between infected and healthy udders, all cows with infected udders should be milked last.

To minimize the spread of disease-producing organisms from cow to cow, separate cloths soaked in a solution of chlorine (250 to 400 parts of chlorine per million parts of water) or quaternary ammonium compounds (a 1:5000 dilution of the active compound or that recommended by the manufacturer for sterilizing dairy equipment) should be used to wipe the teats and udder of each cow before milking. Between milkings the cloths should be washed, boiled, and dried. The teat cups of the milking machine should be submerged in water and then in a solution of aquaternary ammonium compound or chlorine between each cow. The water and disinfectant solution should be changed often.

After the cow is milked, each teat should be immersed in a small amount of the disinfectant solution. That removes from the end of the teat the drop of milk, which tends to attract flies or contaminate the bedding.

The milking machine should be thoroughly cleaned and disinfected between milkings and always kept in good repair. The manufacturer's instructions concerning the rate of pulsations and inches of vacuum must be followed. Teat-cup liners that are dirty or in poor repair, wornout or improperly regulated pulsators, too high or too low vacuum caused by plugged lines, leaky stall cocks, and faulty regulators lower the efficiency of the machine and often cause injury to the teats—thus predisposing the udder to mastitis.

Cows should be handled properly to stimulate the letdown of milk before the milking machine is applied. Complete removal of all milk is also important, particularly for infected cows. After the cow is milked out, the machine should be removed immediately, because teats exposed to the action of milking machines when milk is not flowing through them may be injured.

Other measures that help reduce injuries to the udder and teats are properly constructed stalls, which allow adequate space for each cow; stall partitions, to prevent cows from treading on one another's teats; and a well-bedded, dry floor. Mud holes, high doorsills, and similar obstructions should be removed.

Feeding, age, and heredity may also influence the incidence of udder infections and clinical mastitis in a herd,
but their influence on any immediate problem of mastitis is hard to determine.

People have thought that feeding might stimulate or inhibit mastitic conditions. There is no evidence that any particular feed predisposes the udder to infection. The feeding of high-protein rations or a major change in feeding, as when cows are first turned out to pasture, may result in an increased number of flareups in cows with infected udders. Therefore it is wise to follow regular feeding schedules; use balanced rations, with good and adequate roughage; and avoid all sudden changes in feed.

The number of the udder infections increases with age, when no attempt is made to eradicate the disease from a herd. Some scientists consider that the increased susceptibility to streptococcal infection is independent of environmental conditions and probably results from some change occurring in the cow's udder. Others attribute the increased incidence of mastitis to injury, degree of exposure to infection, and how open or unobstructed the teat canal is.

Heredity may have some bearing on mastitis. Some bovine families are more susceptible than others. Inheritance may determine the shape and structure of the teats, the potency of the bacteriostatic substance in the milk, and the conformation of the udder. Large, pendulous udders are more prone to injury and consequently to infection. Breeding cows for good udder conformation and attachment may reduce the hazard of teat injury and mastitis.

The treatment of mastitis with drugs gives best results when used in conjunction with proper diagnosis, sanitation, and management, and not as a substitute for them.

When only flareups (clinical cases), of mastitis are treated, treatment may give temporary relief to the treated cows, but will do little to solve the problem in the herd. To get maximum results from treatment, all infected cows should be treated at one time to reduce the chances of reinfection.

Before treatment, therefore, a bacteriological examination should be made of the milk from all cows in the herd. It is well to have two or more bacteriological examinations made of the milk after the first treatment or series of treatments so that one can find out which cows did not respond favorably and discover which should be re-treated or eliminated.

One should bear in mind always that cows that have been freed from udder infection may become reinfected if the infection remains in the herd or the organisms normally exist in the barn and pasture.

Cows with severely diseased udders, as evidenced by hardening of the udder tissue, are poor risks for treatment. They do not respond readily to drug therapy. Seldom are they economical producers even if the infection is eliminated. Such cows should be detected by a veterinarian at the time the milk samples are obtained and before any treatment is used.

The main therapeutic agents for treating mastitis are the sulfonamides, nitrofurazone, and the antibiotics, such as tyrothricin, penicillin, streptomycin, Aureomycin, Terramycin, tetracycline, neomycin, bacitracin, polymyxin, and Chloromycetin.

Because no one drug is effective against all the different organisms associated with mastitis, combinations of antibiotics and sulfonamides are used. The combinations show antibacterial activity against more types of organisms than if only one antibiotic is used, and in some cases increase the activity of some of the antibiotics against certain species of bacteria. For instance, when penicillin and streptomycin are combined, smaller amounts of each are needed to show antibacterial activity against staphylococci than if either is used alone.
To obtain best results in treatment, an adequate concentration of the drug must be maintained in the udder for a period of time. Best results are usually obtained when the drugs are administered once or twice daily over a period of 2 to 4 days, depending upon the causative agent and the nature of the case. Most staphylococcal infections must be treated longer than streptococcal infections. Clinical cases must be treated longer than cases not showing symptoms to produce a cure.

Many of the antibiotics are available in various vehicles, such as ointments and water-in-oil emulsions, that are designed for infusion into the udder. The vehicles aid in maintaining an adequate therapeutic level of the antibiotic in the udder for about 24 to 48 hours after one injection. Because antibiotics can persist for several days in the udder, the milk from the treated cows should not be marketed during the period of treatment or for at least 72 hours after the last treatment. The antibiotics interfere with the growth of the bacteria necessary for the production of cheese.

The drugs are administered by infusion into the infected quarter through the teat canal. First, though, the teat must be washed thoroughly and the teat orifice cleansed with a pledget of cotton wetted with alcohol. Because drugs do not cure all infections caused by some of the bacteria and yeasts, the danger exists of introducing these resistant micro-organisms into the udders while treating for another type of organism and of allowing a more severe form of mastitis to develop. Faulty technique in preparing the teat for injection and contamination of the instruments, drug, or vehicle may be to blame.

In treating acute mastitis, it is desirable to have the drugs administered intravenously or intramuscularly, in addition to infusing them into the udder. Frequent milking of the quarter and application of icepacks at the beginning of the attack often are helpful in preventing excessive swelling until veterinary treatment can be obtained. After the cow no longer shows marked symptoms, the application of hot packs to the udder, along with gentle massage, may hasten recovery.

R. W. Brown, Jr., project leader of Mastitis Investigations at the Animal Disease and Parasite Research Branch, Agricultural Research Service, Beltsville, Md., has been engaged in animal disease research since 1947. He has been with the Department of Agriculture since 1951. He is a native of Pennsylvania and received his degree of doctor of veterinary medicine from the University of Pennsylvania in 1945.

Ketosis in Cattle

JOSEPH A. DYE AND ROBERT W. DOUGHERTY

KETOSIS in dairy cattle is not a specific disease but a metabolic disorder. It is an imbalance between the nutritive intake and the nutritive requirements of the animal.

The lack of balance is indicated by several associated disturbances: Low blood glucose levels (hypoglycemia); depletion of liver glycogen (glucose stores); mobilization of body proteins, as amino acids, to the liver for new production of glucose (gluconeogenesis); mobilization of storage fat; fatty infiltration of the liver; increased pro-