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Bovine Mastitis: A major Constraint of Dairy Industry in India

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ABSTRACT

In current scenario most common infection affecting lactating dairy cattle and buffalo is mastitis which is a multi-etiological in nature involving, bacteria, virus, fungi, algae, etc. Farm hygiene plays a major role in prevention and control of mastitis as mastitis causing organism gain access to the intramammary environment via teat canal. Apart, animal breed, age, sex, farm managemental conditions are some of the important risk factor associated with occurrence of mastitis. During intramammary infection pathogens invade the epithelium of udder and destroyed the defense mechanism which further makes the animal susceptible to other infections. Diagnosis of infection can be done by visible examination of milk, udder and animals, various tests to identify abnormal milk composition, somatic cell count, and molecular technique. Various therapeutic protocols are available to treat mastitis but the success rate is very low due to its multietiological nature which makes the selective pin point therapy to fail. Recently, Ethnoveterinary approach to treat mastitis is very common and used across the world. The major advantage of ethnoveterinary approach is free of any side effect which is a common problem during conventional antibiotic therapy. In this review, we have tried to discuss the various aspects of mastitis in India including occurrence, etiology, risk factor, pathogenesis, diagnosis and therapeutic management along with economic importance.

Key words: Mastitis, Intramammary infection, Ethnoveterinary

INTRODUCTION

As we know that livestock and its products are major income source of the poor farmers in most of the developing countries. The dairy industry plays an important role for the livelihood of poor farmers because agriculture land is going to shrink day by day due to increasing population resulting into more dependency of farmers on dairy sector (Braun, 2010). Eighty five percent of dairy animal owners in the country are landless, marginal or small holders with one or two milch animals. Only 5% of the milk producers in India own more than 5 animals.India is the highest milk producer in the world but the per capita availability of milk still remains half of the world average, demanding strategic intervention. One of the reasons for low productivity is poor animal health, particularly, mastitis which is single major constraint in dairy industry in terms of economic losses in India. In dairy cattle mastitis causes severe economic losses in term of reduced milk yield (up to 70%), treatment cost(7%),milk withheld following treatment (9%) and premature culling (14%) (Miller *et al*., 1993). Mastitis is the most economically important disease of dairy cattle, accounting for 38% of the total direct costs of the common production diseases (Kossaibati and Esslemont, 1997).Among the several barriers in peak milk production, mastitis continues to be the most challenging impediment because mastitis affected quarter lose about thirty percent (30%) production and cow may lose about fifteen percent (15%) production (Radistitis *et al.,* 2000).It was estimated in a survey that the average decrease in milk yield due to clinical and subclinical mastitis was 50 and 17.5 %, respectively (Singh and Singh, 1994). The same survey estimatedthe economic loss to be Rs. 6,038.7 and 4,831 million dueto subclinical mastitis and Rs. 2,856.4 and Rs. 2,345.9 millions due to clinical mastitis in cattle and buffaloes,respectively.The total loss due to both forms of mastitis (Clinical as well as Subclinical) has increased almost from Rs. 16,072 millions to Rs. 71,655 millions in a span of just 15 years.As per 2006 estimates referred in ICAR's National Agricultural Innovation Project, the estimated annual loss due to mastitis alone is approximately Rs16,702 millions. According to some previous reports the annual economic losses due to bovine mastitis was increased 114 folds from 1962 (INR 529 million/annum) to 2001 (INR 60532 million/annum). According to a study, the estimated loss of milk after clinical mastitis in cattle was approximately 700 kg in first lactation and 1,200 kg in the second or higher lactation (Wilson et. al., 2004).Total economic loss in India due to mastitis is reported as $526 million while in USA it is $2 billion(Varshney and Naresh 2004; Donovan et al. 2005).In the USA, sub-clinical mastitis alone causes 60-70 percent of total economic losses associated with all mastitic infections (Merrill and Galton, 1989). It was estimated that prevalence of bovine mastitis ranged from 29.34 to 78.54% (Sharma and Maiti, 2010) in cows and 27.36 to 70.32% (Beheshti *et al*., 2010) in buffaloes. Risk factors such as management practices, host and diet have been reported to be important in the prevalence and epidemiology of both clinical and sub-clinical mastitis.Some of the important contributing factors for increase incidence of mastitis are Lack of awareness, late detection of sub-clinical mastitis, lack of markers for detecting ensuing mastitis,unhygienic milking practices,inadequate treatment etc.

According to National Mastitis Council mastitis is an inflammatory condition of the mammary gland in response to injury for the purpose of neutralizing the infectious agents and to prepare the way for healing and return to normal function. Mastitis is an inflammatory condition of mammary parenchyma irrespective of their causes, characterized by physical, chemical and biological changes in milk and glandular tissue of mammary gland. The most common changes in the milk include discoloration, presence of clots and the presence of large numbers of somatic cells i.e. leukocytes. The magnitude of these changes in individual animal varies with the severity and duration of the infection and the etiological agent involved. Previously, the physical factors like cold and mechanical damage to udder or teat were considered as causative factor of mastitis but now it has been proved by Frank in 1987 that mastitis is an infectious disease which can be transmitted from infected quarter to healthy one by inoculating material from infected to healthy one.

Etiology

Mastitis is multietiological in nature and caused by number of pathogens (>200 infectious cause) like bacteria (Primarily), virus, algae, fungi, etc. Primary bacteria involved are Coagulase Negative Staphylococci (Sharma et. al., 2012) *Streptococcus dysgalactiae* (Kumar *et al*. (2009) and *S. aureus.* Besides, other bacteria such as Nocardia, Histophilus, Pasteurella, Campylobacter, Proteus etc. also cause sporadic mastitis. The mastitis causing pathogens are further classified as major pathogen (*E. coli, Klebsiella pneumoniae, Enterobacteraerogenes, Streptococci* etc.) and minor pathogens (*Staphylococcus hyicus and Staphylococcus chromogenes etc*) causes clinical and subclinical mastitis (except *C. bovis*) respectively. Based on the visible changes in milk and symptoms present/absent, mastitis may be clinical or subclinical (more common) with greater loss in later one (Schultz *et al*., 1978). Clinical mastitis is characterized by presence of all cardinal signs of udder inflammation (redness, heat, swelling, pain and loss of milk production) and is categorized as peracute, acute, subacute and chronic form while the subclinical form is devoid of any obvious manifestation of inflammation.

Risk factor

Various risk factors are associated with occurrence of mastitis including animal related risk factor, environmental factors and pathogen risk factor. Animal risk factors includes age and parity of animal, stage of lactation, breed, udder morphology, udder hygiene, milking practices, nutritional status of animal, resistant for mastitis etc. It was studied that the prevalence of mastitis increases with age and parity of animal. New infection of mastitis occurs most commonly during early dry period or during first 60 days of lactation due to delay in neutrophil migration. It was also accepted that the incidence of mastitis is somewhat greater in Holstein-Friesians than in Jerseys but authentication is still required regarding this fact. Animal with large diameter teat canal and less teat end to floor distance is associated with greater incidence of mastitis. Animals fed on good quality ration having sufficient amount of vitamin E and selenium are less prone to intramammary infection. Some previous studies also suggested that the animal suffered with ketosis also becomes more prone to mastitis because immune cells type and their response are adversely affected by increased ketone bodies and lowered concentration of glucose (Suriyasathaporn et al. 2000). Environmental factor includes housing and managemental practices, milking practices and season etc. it was proved in literature that organic bedding material (sawdust, wood straw etc) are favorable for the multiplication of mastitis pathogens while inorganic bedding material provide unfavorable environment for mastitis pathogen. Use of milking machine for commercial dairy farm makes the herd more susceptible for mastitis. Milking pain should be cleaned every time before milking to reduce the incidence of mastitis. Pathogen risk factors include viability and virulence of pathogens. Viability means survival capacity of pathogen in herd environment like bedding and disinfectant materials. More is the viability of pathogen in herd environment more will be the incidence of mastitis. Virulence of pathogen means their ability to infect and produce the disease in host. It depends on different factors like their colonizing ability, toxin production ability and capability to adherence the alveolar epithelium of mammary gland. Different pathogens have different virulence which is responsible for the different epidemiological characteristics of the organisms in some herds.

Pathogenesis

The teat end acts as body's first line of defense against infection. A smooth muscled sphincter, which surrounds the teat canal, functions to prevents bacteria from entering the teat.

The cells lining the teat canal produce a bacteriostatic fibrous protein which forms a barrier against bacteria. Whenever any trauma in teat is caused by incorrect use of udder washes, wet teats, improper mixing or freezing of teat dips, frostbite and insertion of mastitis tubes or teat cannulae, there is more chances of bacterial invasion, colonization, and infection because of damage to keratin,lining the teat sinus.These microorganisms multiply and produce toxins and enzymes which stimulate the production of numerous inflammatory mediators by inflammatory cells (mainly Polymorphonuclear neutrophil and phagocytes) which in turn causes damage to milk producing tissue of the mammary gland. Etiological agent, stage of lactation, age, immune status of the cow and nutritional status decides the magnitude of inflammatory response produced. Sometime these PMN cells pass between milk producing cells intothe lumen of the alveolus causing increase in somatic cell count (SCC) which remains in large concentrations after bacteria are eliminated until healing of the gland occurs. In some cases these leukocytes form a clot inside the small ducts and prevent complete milk ejection. Damage to epithelium and blockage of small ducts can result in the formation of scar tissue and permanent loss of function of that portion of the gland. In some cases inflammation may subside, tissue repair may occur, and function may return in same lactation or the subsequent one (Harmon, 1994).The inflammation contributes to decreased milk production and is primarily responsible for the compositional changes observed in milk from infected quarters and cows. In general, compositional changes involve an increase in blood components present in milk and a decrease in normal milk constituents(Motwani, 2011).The bacterial contamination of milk from the affected cows renders it unfit for human consumption and also spread many diseases like tuberculosis, sore-throat, Q-fever, brucellosis, leptospirosis etc. with zoonotic importance (Sharif *et al*., 2009). In addition to decrease in milk production and compositional changes in milk, it also causes severe irreversible damage to the udder tissue by destroying milk secreting glands in udder and their replacement with scar or connective tissue. Bacterial toxins released during mastitis stimulate the production of prostaglandin F2 α, which subsequently causes luteal regression, resulting into abortion (Lavon et. al., 2008). Some bacterial endotoxin (E. coli) produces bioactive molecules like cytokines which play very important role in generating inflammatory reaction, reduced pulsatile secretion of luteinizing hormone (LH), significant decrease in the ovulatory LH peak, decreased estradiol production (decreased estrus expression) and failure of ovulation (Lopez, 2013).Mastitis also affects the probability of conception based on the time of occurrence of mastitis before, within or after a week of insemination. It was concluded that probability of conception decreased by 44% when mastitis occurred a week before insemination, by 73% when it occurred during the week of insemination, and by 52% when mastitis occurred during the week after insemination. Milk from mastitis affected quarter is much different from that of healthy quarter because of presence of various normal blood components in milk like leukocytes (PMN cells, lymphocytes and macrophages), albumin, immunoglobulin, transferrin and other serum protein due to altered vascular permeability. In mastitis, normal milk components are decreased and blood components are increased leading to compositional changes of milk. Presence of leukocytes results into increase in somatic cell count (SCC). In mastitis affected quarter the milk contains lower concentration of casein (a major milk protein) and higher concentration of whey protein which adversely affects qualityof dairy product like cheese, butter, etc. Plasmin, a proteolytic enzyme derived from somatic cells degrades the casein of milk which in turn also affects the quality of dairy products. Due to increased vascular permeability in mastitis different ions like sodium and chloride passes into milk which leads to increased electrical conductivity of mastitis milk. In contrast, potassium is predominant in normal milk but during mastitis its normal concentration decreased. Since most of the calcium in milk is casein bound its level also decreases in mastitis milk.

Diagnosis

Traditional methods for the diagnosis of mastitis are estimation of somatic cell count, estimation of certain biomarkers associated with mastitis (N-acetyl-β-D-glucosaminidase and lactate dehydrogenase) and isolation, identification and characterization of etiological agent by microbiological culture (Lam, 2010). Since these tests has some restrictions, their application at field level is not practically possible so there is urgent need to develop rapid, specific, sensitive and reliable diagnostic test which can be performed under field conditions.Besides these, some ‘‘cow side’’ tests such as theCalifornia Mastitis Test (CMT) and measuring the EC of milk can also be used for the diagnosis of mastitis. In developed countries various automated system are applied for routine screening of animals for milk somatic cell count (SCC) but in India no such routine practice is common due to owing small scale dairy farms units. Hence some common parameters like Somatic Cell Count (SCC), Electrical Conductivity (EC) and pH are generally employed in small scale dairy industries.The development of tools to detect "ongoing" mastitis in a cow at the "cow side" is the most suitable option to reduce the loss due to this disease. Clinical mastitis is easy to detect and hence immediate treatment is possible but the subclinical mastitis, on the other hand, is difficult to diagnose without routine surveillance and monitoring (Wilson et. al. 1997). A study was conducted at TVCC, VCRI, Namakkal, reported the prevalence of mastitis due to *E. coli* was 10.57% when identified by isolation on selective media and confirmed by PCR test (Navaneethan et. al., 2017). The International Dairy Federation recommends that the diagnosis of mastitis be based on the SCC and microbiological status. Recently, more advance methods for accurate identification of mastitis develops which includes estimation of mastitis associated novel biomarkers and combinations of conventional tests in sensor based platforms. In large scale dairy industries mastitis detection by enzymatic assays, immune assays, biosensors and nucleic acid tests is another important alternate way. Now a day some automated milking farms develops electronic tongue or nose which can differentiate mastitis milk from normal milk based on organic and inorganic cations and anions, and volatile substances. While working on the diagnostic approach for mastitis it is very important for anyone to identify the etiological agent involved in the development of mastitis. A reliable etiological analysis must identify the causing agent. One such technique is real time PCR assays performed directly on milk samples (without culturing) which is advantageous over conventional culture, due to higher speed, automated interpretation of results, and increased sensitivity (Koskinen *et al.,* 2010).However, one major disadvantage associated with this technique is that it may detect the DNA of dead bacteria and free DNA present in high quantity in milk thus reducing its specificity (Perez *et al.,* 2007) as a consequence, bacterial cultures are still required for routine etiological diagnosis of mastitis.Another way regarding this approach is the introduction of molecular microbiology techniques such as PCR and matrix-assisted laser desorption/ionization time-of-flight mass spectrometry (MALDI-TOF MS) have improved the sensitivity, specificity, and processing time of bacterial identification procedures (Barreiro *et al.,* 2010). More recently, microbial identification techniques, based on pyro-sequencing of the 16S ribosomal RNA gene, were used to obtain a description of the milk microbes (Hunt *et al.,* 2011).

Therapeutic management

Specific protocol should be adopted for the treatment of clinical and subclinical mastitis.Before initiating the treatment a veterinarian must be clear in mind that which pathogen is involve in causing mastitis, type and severity of infection, stage of lactation, duration of infection etc. Further it should also be clear that treatment will performed at individual cow level or at herd level because it ultimately affects economy of farmers. In a herd with low bulk tank milk SCC and sporadic case of environmental mastitis the treatment protocol should be limited to lactating cow therapy at individual level with the treatment objective of alleviating clinical signs and return to normal production. The herd, on the other hand, with moderate to high bulk tank milk SCC and a significantprevalence of contagious organismsshould aim the treatment strategy at the herd level the objective to prevent the spread of infection, eradicate a specific pathogenand increase herd production. Next to these another important decision is to select the route of administration of antimicrobial agents because the primary goal of administration of antibiotics is to achieve and maintain the effective concentration at the site of infection. Since ancient time the holistic approach towards treating the mastitis is use of antimicrobial agents either by parental or intramammary rout. However, there is no rationalization on the use of freely available and new generation antibiotics exist. Under field condition the primary approach to treat mastitis is use of broad spectrum antibiotics because the veterinarians avoid taking chances which may further causes more financial loss of farmers. But indiscriminate use of antimicrobial agent has many disadvantages like higher cost of treatment, long duration of treatment so more loss of milk due to residual effect and perhaps, the most important, development of resistance to particular antibiotic so it would be a better option to select antibiotic after applying filed antibiotic sensitivity kit which costs around Rs. 150 for five antibiotics with additional Rs. 25 per any additional antibiotic requirement.Response of antimicrobial agents is generally accessed on the basis of clinical outcome or cure. But two important aspects for judging the efficacy of treatment are "clinical cure" and "bacteriological cure."Clinical cure means return to normal milk after treatment which is more important in most of the dairy industries. Bacteriological cure, on the other hand, is defined as the condition after 2-4 week of treatment when it is impossible to isolate the initial pathogenic organism in milk culture. Most veterinarians judge the efficacy of antimicrobial agent on the basis of physical appearance of animal as well as milk after treatment because most of the milk producers in India are interested in thereturn to normal milk (clinical cure) andare much less interested in the return to asterile quarter (bacteriological cure). Sub clinical mastitis remains undiagnosed since no apparent change in milk seen and hence causes more loss to farmers. Best way to treat subclinical mastitis due to contagious pathogen is to perform dry cow therapy which includes intramammary infusion of long acting antimicrobial agent at drying off. A new approach towards the advancement of veterinary medicine is use of medicinal plants for the treatment of disease known as "ethenoveterinary medicine." Farmers generally depend on antibiotic (Ceftiofur, Cefquinome and Ceftriaxone & Tazobactum combinations etc) as first choice of treatment but it cost much more and also bacterial resistance iscommon problem causing failure of treatment (wang *et al*., 2013).Previous studies suggested that minimum five days treatment is required for satisfactory result while treating mastitis by using antibiotics hence loss of nearly Rs. 3000/- per animal which is hardly possible to afford by poor farmers. One more constraint in this regard is poor availability of antibiotics in rural areas hence delay in the treatment will also cause more financial loss to the farmers in term of extended treatment duration, more udder damage and loss of milk due to residual effect.Traditional medicines, On the other hand, are prepared from plants and their part which are easily accessible to the farmers in their local environment. In India, not only mastitis but several other conditions can also be managed by using different herbal medicines. Literature also evident high cure rate of mastitis affected animals by using ethenoveterinary medicine without use of any antibiotic. Although ethenoveterinary medicine, in treating mastitis, is beneficial way to help poor farmers in increasing their income, it need to be promoted by different veterinary institutions, NGOs, privet clinics, dairy farms and obviously, the most important by field veterinarians. Currently some Institutes like the Tamilnadu Veterinary and Animal Sciences University,Chennai and the Transdisciplinary University, Bengaluru, promoteethnoveterinary medicine (EVM) for managing different diseased conditions in animalsincluding mastitis.

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Author Contributions

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