Zoonotic Diseases Caused by Mastitic Milk

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ABSTRACT

Mastitis is inflammation of animals udder or mammary gland occur due to bacterial invasion followed by injury and it is the infectious zoonotic disease caused by the consumption of raw milk. Consumption of this raw milk led to many zoonotic diseases like bovine tuberculosis, listeriosis, brucellosis, Q fever, salmonellosis, leptospirosis and mycoplasma infections. Bovine tuberculosis in mammals caused by Mycobacterium bovis and it primarily affect upper and lower respiratory tract. Listeriosis is caused by listeria monocytogenes and it mainly cause damage to the CNS of animal. Q fever caused by coxialla burnetti which is highly resistant to environment and more dangerous for pregnant animals and cause pre mature birth or abortion and human get infection by respiratory route. Salmonellosis is caused by bacteria of the genus Salmonella belongs to the family Enterobacteriaceae and affect broad host spectrum. Salmonella is the major cause of intestinal infection in many hosts. Raw milk and milk products and uncooked meat is the main cause of these infections. These results in great economical loses and preventer by taking hygienic measures and consumption of properly cooked meat and pasteurized milk.

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1. INTRODUCTION

Mastitis is the inflammation of the udder or mammary gland of animals caused by the invasion of pathogenic bacteria followed by injury (Jiang et al. 2023). Unhygienic practices adopt during milking at farms lead to the spread and proliferation of pathogenic bacteria (Pal et al. 2023). Mastitis is the infectious zoonotic disease that causes infections through milking machines or milker's hands. In contrast, zoonosis in humans is caused by the consumption of raw, apparently hygienic, or unpasteurized milk (Schoder et al. 2023). Physical, chemical, cellular, and microbiological changes in mastitic milk cause economic losses worldwide and promote reduced reproductive life span of suffered animals (Joy et al. 2023). Many outbreaks have occurred due to unpasteurized mastitic milk (Dendani and Arcangioli 2023). This milk led to many zoonotic diseases like Brucellosis, Mycoplasma infections, tuberculosis and leptospirosis. Mastitic milk is the major cause of livestock diseases. *E.coli*, *Staphylococcus (S.) agalactiae*, *S. dysgalactiae*, *S. uberis*, and *S. aureus*, constitute 95% of all infectious diseases (Nobrega et al. 2023). Bovine sources cause approximately 65000 deaths of people suffering from tuberculosis in Wales and England between 1912 and 1937. In 1938, prior to World War II, milk borne outbreaks consisted of 25% of all outbreaks (Loddenkemper and Konietzko 2018). The prevalence level of *Listeria monocytogenese* and *Campylobacter jejuni* in milk is 13% (Jayarao et al. 2006).

1.1. BOVINE TUBERCULOSIS

Mycobacterium bovis complex contains the mycobacteria that cause tuberculosis with the wide range of host. The upper and lower respiratory tract and lymph nodes are affected with gross lesions. Transmission occurs via different routes of dairy products. The disease can be diagnosed by clinical signs and tuberculin skin tests in live animals and postmortem after death. It is of great public health significance to the people closely associated with animals (Al-Asady and Ali 2023).

1.2. ETIOLOGY

The *Mycobacterium (M.) bovis* comprises all of the mycobacteria that cause tuberculosis in mammals except the *M. avium* that caused the disease in birds (Javed et al. 2023). *M. bovis* is primarily responsible for infection in cattle (Parija 2023a). A zoonotic aspect of tuberculosis in humans is also related to the *M. bovis* that is responsible for bovine tuberculosis, causing chronic, progressive disease and primary disease in the respiratory system. It has a wide range of hosts, including humans, domesticated animals and wild animals. *M. bovis* is a considerable risk for human tuberculosis but does not establish as readily as *M. tuberculosis* in humans.

1.3. HOST SPECIFICITY

Bovine TB is one of the zoonotic diseases that impact livestock and humans and results in great production and economic losses in livestock (Bezos et al. 2023). M. bovis has a broad range of hosts than M. tuberculosis (Guimaraes et al. 2023). Table 1 highlights the hosts for *M. bovis.*

If amplifier hosts are infected, these can cause disease among animals and humans (Labruna 2009).

1.4. LESION DEVELOPMENT

M. bovis grows intracellularly in macrophages, the primary host cell (Verbeke et al. 2023). Experimentally, gross lesions can be seen in the respiratory tract and associated lymph nodes 14 days after infection. The caseous core lesions were small, light yellowish in color , and macrophage giant cells and neutrophilic

Table 1: Hosts of *M. bovis*

Natural host	Domestic cattle's.
Maintenance host	Captive deer and goats. European wild boar in Spain, New Zealand Brush-tailed possum, the European badger in the United Kingdom, Cape buffalo, and antelope in southern Africa are also the maintenance hosts for *M. bovis* (de Lisle et al. 2001).
Dead end host	Horses and sheep are among domestic animals (Coleman and Cooke 2001).
Amplifier host	Pigs, camelids, dogs, cats, goats, and farmed wild boars (Broughan et al. 2013).

debris were in evidence. Some mineralization and fibrosis were seen with developing lesions and more extensive necrosis consisting of intact and degenerative neutrophils, macrophages, and lymphocytes. Respiratory tract is infected in both direct and indirect contact. A very small dose can cause the infection through respiration that can be 1000 times less than the intestinal route (Hope et al. 2023).

1.5. TRANSMISSION

Milk is a route of transmission from a diseased cow to humans. Other common routes are ingesting raw milk and milk products and professional contact with infected animals. Routes of transmission are:

1.5.1. INGESTION (MILK AND MILK PRODUCTS)

Consumption of raw milk is the main source of infection from infected cattle to humans as mycobacteria can persist in unpasteurized milk (Islam et al. 2023). But once pasteurized, it becomes inactive. Many bacteria are shed in tuberculosis mastitis milk that is enough to infect the milk pool of 100 milking cows. Milk product like cheese from unpasteurized milk is also a risk for the population. Bacteria persist in unpasteurized milk and are less likely to be affected by pH, acid, alkali, and chemical disinfectants. *M. bovis* can persist for longer times in different varieties of products obtained from unpasteurized milk (Zeineldin et al. 2023).

1.5.2. INGESTION (MEAT AND MEAT PRODUCTS)

Eating the undercooked meat of affected animal can be a source of infection in humans. It is not an affective route as tuberculous lesions are not present in skeletal muscles. It's only possible in case of very advanced infection. During the meat inspection, the affected parts are removed, and if more than 1 organ or carcass is affected the whole carcass and offal are condemned. *M. bovis* is very sensitive to heat and cooking the meat at more than 60^0C temperature can result in no viable unit of *M. bovis* (Ahmad et al. 2023).

1.5.3. RESPIRATORY ROUTE

Respiratory route is common for animal-to-animal transmission. Professional zoonosis in those occupations and being exposed to aerosols is the route for human infection (Anderson et al. 2023).

1.5.4. CUTANEOUS/MUCOSAL TRANSMISSION

It is a rare route of transmission and has historical interest where it was an occasional source of localized skin, tendon and lymph node lesions, otitis, and conjunctivitis in milkers and veterinarians during surgical interventions (Phillips et al. 2003).

1.6. SING AND SYMPTOMS

The organ systems affected determines the sign and symptoms:

- In early stages, Tuberculous animals are clinically normal and no clinical evidence can be seen (Dinh-Hung et al. 2023).
- Progressive weakness, debility and mild fluctuating fever are the gradual onsetting signs.
- When there is lungs involvement, reduced exercise tolerance, dyspnea, and chronic moist cough more noticeable in morning and cold weather. Lymph nodes of head may swell and signs of obstruction of affected organs are seen when internal lymph nodes swell.
- Gastrointestinal involvement causes diarrhea or constipation.
- Persistent mastitis and hypertrophy may result from mammary tuberculosis that seen in varying populations of animals.
- Tuberculosis metritis may result in infertility and abortion, and chronic purulent vaginal discharge can be seen.
- Military tuberculosis caused by a hematogenous route can result in acute or subacute death from primary or secondary lesions (Nguyen et al. 2023).

1.7. PUBLIC HEALTH SIGNIFICANCE

Zoonotic tuberculosis is of public health concern in the whole world. More seen in developing countries (10-15%). Risk factors in developing countries include

- Human immunodeficiency virus (HIV).
- Poverty.
- Raw or undercooked dairy products.
- Social and cultural factors such as consuming raw blood.

Veterinarians, farmers, milkers, and abattoir workers are at risk from any route like inhalational, ingestion or cutaneous. Milk of affected mastitic cows can contaminate whole milk of 100 cows (Du et al. 2023).

1.8. DIAGNOSIS

Different methods are used in live and dead animals for the diagnosis of tuberculosis. The disease is manifested by clinical signs in live animals, and a Tuberculin skin test is also used (Gomez-Buendia et al. 2023).

1.9. TUBERCULIN SKIN TEST

This test measures delayed responsiveness to hypersensitivity**.** Tuberculin, purified protein derivative (PPD), is injected intradermally and recognized by World Health Organization. Single intradermal test (SITT) and comparative intradermal test (CITT) are two variations of this test. In the SITT method, PPD-B is injected at the neck region. A positive test is considered in case of selling at the injection site. It is measured by pairs of calipers before and after 72 hours of injection. More than 4mm thickness change indicates a positive for *M. bovis* infection. CITT is used to differentiate the animals affected with nontuberculous mycobacteria. This test addresses the cross-reaction between *M. bovis* and *M. avium*. PPD-B and PPD-A are injected side by side at 12cm difference and skin swelling is measured after 72 hours. The test is considered positive if swelling at PPD-B is more than 4mm than at PPD-A site (Shukla et al. 2016).

1.10. CONTROL

Adapting the control measures has lowered the number of infections. Effective disinfectants such as phenol, glutaraldehyde, iodine, and formaldehyde are used. Also, a heat of 250^0 F is effective. Due to infectious nature of the disease, no treatment is recommended. Long-term therapies are used to treat the condition. Pyrazinamide, an anti-tuberculosis drug, is ineffective against *M. bovis*, but rifampicin and isoniazid are effective (Zhang and Mitchison 2003).
A vaccine could be the preventive option, but it only reduces the severity of the disease, not prevent it entirely. The vaccine was developed in the 1920s by Calmette and Guerin. Another way is to inhibit direct contact of deer with cattle. Avoid offering deer saliva mixed fodder to cattle.

1.11. LISTERIOSIS

Clinical Signs of listeriosis and prevalence and incidence in dairy cattle in England in 1500 dairy farms were investigated with the help of a postal questionnaire survey. 64.1% was the response rate. The emerging zoonotic infection of ruminants is listeriosis, and the causative agent is *Listeria (L.) monocytogenes* (LM). Listeria affects CNS pathology (neuropathology), including rhombencephalitis. Lineage 3 of the Listeria monocytogenes serotype 4b strain is the cause of Listeria (Bundrant et al. 2011). Continued checking of animal listeriosis cases or outbreaks is necessary to improve animal health.

1.12. ETIOLOGY

Most of the animal listeriosis cases are caused by lineage 3 and 4. Contaminated silage is the number one cause of listeriosis. Contamination of the raw materials, wildlife or bird feces, or manure is also a cause of listeriosis. pH more significant than 5 of improperly fermented silage is a source for the growth of Listeria monocytogenes.0.1 billion colony forming units (CFU) /g is the number for Listeria monocytogenes in the poorly fermented silage. Morbidity is 8-10 percent, and mortality is 15 percent. Animals showing no clinical signs may also be a source of *L. monocytogenes*. *L. monocytogenes* is known as a harmful bacterial pathogen and has been a major case of food-borne diseases (Meurer et al. 2023).

1.13. HOST SPECTRUM

In immunocompromised adults, Listeria monocytogenes is a virulent bacterium that causes a number of food-borne diseases with very high mortality rates. Food-borne infection is a case for miscarriage (abortions) in pregnant women. Immunocompetent individuals cause localized gastrointestinal symptoms (Allahverdy and Rashid 2023).

1.14. EPIDEMIOLOGY

L. monocytogenes have different serotypes usually isolated from foods, large number of clinical cases in the world are due to set of serotypes (e.g., 1/2 a, 1/2 b, 4 b). Listeriosis related subsets of serotypes are 1/2a and 4 b (Brown et al. 2023).

1.15. ECONOMIC IMPACT

So, if marginal benefit is equal to marginal cost, then the level of food safety measurement is optimum. Benefits and costs of L. monocytogenes are estimated from published literature, different methods of economic analysis. Annually benefits for Listeria monocytogenes estimated measures range between 2.3 to 22 billion dollars (Koopmans et al. 2023).

1.16. TEST FOR LISTERIA MONOCYTOGENES DETECTION

16. 1. PROCEDURE

For virulence of genes DNA sequencing data actA and inlA were used for phylogeny of Listeria monocytogenes and to test for positive result selection. For the absence or presence of genes, isolates were screened and assigned an internalin profile. To find out each isolate's relative cytopathology, plaquing assays should be performed (Wang et al. 2023b).

16.2. RESULTS

Listeria monocytogenes represents 2 separated evolutionary lineages results confirmed that. Under positive selection genes actA and inlA consist of amino acid sites. At some places, specific residues are associated by lineage and manifested of listeriosis. Predominantly and clonal composition of isolates from case of encephalitis was lineage 1. Just Genetically more modified and equally represented by isolates from case of encephalitis versus septicemia and fetus infection is lineage 2. Lineage 2 has lessee cytopathology in vitro as compared to lineage 1isolates (Hou 2023).

1.17. SUBTYPING OF UNUSUAL STRAIN

Main subtyping methods are of 2 types:
1. Bases of DNA sequencing on a 660 base pairs_ sigB allelic typing.
2. Used partial sequencing of sigB, addB, Idh, pbpA, lmo0490, lmao 2763, polC, prs, rarA, lmo1555 _subtyping by a 10-locus MLSA scheme.

Polymerase chain reaction of target genes by dideoxynucleosides a cause for obtaining sequence data for these genes (Hou 2023).

1.18. CLINICAL SIGNS

Broad range of clinical signs are linked to Listeria monocytogenes starting from a healthy fecal carrier state and non- invasive disease to invasive systemic disease infections. Abortions and stillbirths in sheep are also caused by Listeria spp. Tissue specificity in mammalian hosts is caused by Listeria monocytogenes. Virulence of pathogens varies with different factors. By bacteriology and histopathological test of fixed CNS tissues from single disease animal clinical diagnose of encephalitic listeriosis (circling disease). As the abscesses are mostly linked with encephalitis listeriosis (Subramaniyan et al. 2023).

1.19. PREVENTION AND CONTROL

Natural environment includes sea water, and fresh water of these areas are widely distributed by Listeria monocytogenes. During processing pollution and contamination of food present on sea may happen to occur and on seafoods very less levels (less than 100 CFU /g) for *L. monocytogenes* are frequently present. There are some options for prevention of Listeria monocytogenes from equipment or foods, other than heat treatment, that is also very effective. To minimize the multiplication of Listeria monocytogenes in the final product is therefore essential. Cleaning and sanitizing program are included in the preventive measures, designed for decreasing the number of *L. monocytogenes* in the factories environment (Gómez-Galindo et al. 2023).

1.20. TREATMENT

- Ampicillin (Seki et al. 2023)
- Gentamicin (Li et al. 2023)
- Trimethoprim- sulfamethoxazole (Wang et al. 2023a)

2. Q FEVER

The zoonotic disorder Q fever is a disease that occurs by a gram-negative type bacterium, *Coxiella (C.) burnetti* that is present in the environment, all around (Navaei 2023). Transmission to the humans is mainly by the respiratory route by inhalation of aerosols, and the consumption of the contaminated products of the animals the reservoirs include the cattle and other pets. The Q Fever is exceedingly asymptomatic. However, in humans it may show symptoms from acute to chronic. The chronic symptoms include endocarditis mainly and are observed in patients with previous valvopathy and immunocompromised hists as well as pregnant. The treatment is effective but should be chosen according to the acute or chronic status of disease. Vaccination of animals can prevent the shedding of bacteria as well as abortions in the animals (Statham 2023).

2.1. HISTORY AND BACKGROUND

Different researchers have worked on Q Fever in different eras. Edward Holbrook Derrick 1937 described the febrile disease in Queensland, Brisbane, and Australia slaughterhouse workers. He was invited to investigate the outbreak in Brisbane and tried to isolate the causative agent of febrile disease by inoculating the guinea pigs, but failed. The etiological agent of the disease was first named as *Rickettsia burnetii* (Zhang et al. 2023) but in 1938 a new genus Coxeilla proposed by D. Phillip suggested the name *Coxiella burnetti* (Bell and Philip 1952), a name honoring the cox and burnetti who identified Q fever agent the new Rickettsial specie.

2.2. HOST SPECTRUM

The hosts for Q fever includes the humans, ruminants, pets but the common host cattle sheep and goat and rarely reptiles and birds. The causative agent is shed in the urine, feaces, milk and birth products (Van den Brom and Vellema 2009).

2.3. EPIDEMIOLOGY

The respiratory route is the basic route of contamination in humans, contamination by aerosols occurs directly from the birth products of the animals. The *C. burnetti* is very resistant to the environmental factors and may survive for weeks in the places where animals are present. Ingestion is small less important factor previously but is now a controversial topic these days. *C. burnetti* has been found in the arthropods as well, specifically in ticks but arthropods caused disease is not significant in the humans. Two cases were reported in the France caused by Rickettsia conorii and *C. burnetii*. Sexual transmission remains confined to the humans and animals. Sexual Experiments on infected mice were failed (Pires et al. 2023).

2.4. BACTERIOLOGY

It is an obligate intra-cellular, Gram negative type of bacteria from Legionellae's order, was observed in the rickettsia-like organism in liver and spleen of mice and was inoculated in their urines, first time. The major target cells are those located in the body tissues liver, lungs, spleen and lymph nodes and the monocytes circulating in the blood stream. Two different Antigenic forms have been found of *C. burnetti* and are distinguished on the basis of surface lipopolysaccharides. Phase I is the virulent type that completes the LPS on their surface, while the phase II is non virulent, having incomplete LPS and is non virulent (Metters et al. 2023).

2.5. ANIMALS

2.5.1. CATTLE

Q fever is widespread in cattle but is asymptomatic. Clinical manifestations include the premature delivery, Birth of weak off-spring and Abortion. *C. burnetti* is significantly associated with the Placentitis. Unlike humans, Cattle do not show the respiratory signs. Study by Guatteo show that milk is the 45% shedder and is the more positive for the samples as compared to the feaces or vaginal samples. Pregnant animals are high at risk as compared to non-pregnant animals. A combined shedding of virulent micro-organism in vaginal secretions and in feaces is 14.6% and 10% of cases, respectively (Porter et al. 2011).

2. 6. SHEEP AND GOAT

pneumonia, still births, Abortions and delivery of weak offspring are the results of the Q fever in Goats. In many countries, Goats cause the zoonotic effect to humans as their close contact and raising. Similar to cattle, Pregnant animals are high at risk as compared to non-pregnant animals. Animals may acquire the infection in the uterus and the mammary Gland (Lang 1990).

2.7. SHEEPS

Show the chronic infections due to *C. burnetii* caused Q fever. It results in the abortions similar to goats, and shed the microorganism in the vaginal secretions, feaces and urine but to a lesser stretch in milk (Gilsdorf et al. 2008).

2.8. CATS AND DOGS

Q fever is prevalent with the pets so is associated with the humans, in developed and under developed areas.

In the Feline family, the Q fever does not show any symptoms so remains undiagnosed, but the infected organism sheds the *C. burnetti* in the environment and plays the major role in zoonosis. Studies show that seroprevalence was high in the street cats as compared to the domestic cats (Kilic et al. 2008).

In Dogs, infection occurs potentially by the inhalation of spores of *C. burnetti*, bite of ticks, consumption of infected placentas and milk from the infected ruminants. The parturient dogs show the highly affected rate, puppies mostly die within 24 hours of birth, since it is associated with the early death of the puppies (Paris and Day 2023).

2.9. HORSES

Equine family shows the positive results for the presence of *C. burnetti*. But there is no zoonotic linkage is found between human and equines (Özcelik et al. 2023).

2.10. WILD ANIMALS

Wild life is considered less important for the Q fever zoonosis. Many wild birds and other mammals have been found to be the hosts of the infectious organisms but do not show the disease symptoms.

2.11. HUMANS

In humans, the Q fever shows the different types. It causes the acute to chronic disease in humans. The incubation period of 1-3 weeks is required to cause the disease.

In acute q fever, infection is totally asymptomatic in half of the cases, but if show, the symptoms include the fatigue, fever, headache, and influenza like symptoms. Pneumonia is the important symptom shown by the humans. It causes the abortions, intra uterine fetal death, premature birth and uterine growth retardation. The death rates in Q fever are only 1-2% while myocarditis occurs in less than 1% cases (Magdalini et al. 2023).

2.12. CHRONIC Q FEVER

The persistent infection for 6 months results in the chronic case of Q fever. Inflammation of internal lining of heart walls and chambers is observed and which occurs in 60-70% of cases, in chronic Q fever. The main symptoms observed are neurological. Headache, confusion, behavioral problems, and convulsions can be seen. In the pregnant mothers, future abortions are expected if infected with the Q fever. Antibiotic treatment is less effective and morality rates hit more than 50% (Debowski et al. 2023). Table 2 shows the affected species, symptoms and clinical manifestations.

Table 2: Species affected, disease symptoms and clinical manifestation

Specie	Symptoms	Clinical manifestations
Cattle	Asymptomatic (mostly)	Problems with the newborn
Sheep & Goat	Uterus & mammary gland	Pneumonia, New born issues
Cats & Dogs	Asymptomatic	Puppies died 24 hrs.
Wild Animals	No disease symptoms	
Humans	Polymorphic	Fatigue, Fever, Endocarditis

2.13. PREVENTION AND PREDISPOSING FACTORS

The general preventions include the avoiding contact with the livestock, not getting contaminated with the birth fluids of the animals, consuming pasteurized milk and milk products. Moreover, Q VAX vaccines are also in practice since 1989. After the use of vaccines, the positive cases of Q fever have markedly dropped (Chow et al. 2023).

2.14. TREATMENT

Doxycycline is used for 14 to 21 days in non-gestating females and other patients. Hydrochloroquines are also in practice, phagolysosome pH is increased and the association with the doxycycline bactericidal effect.

Fluoroquinolones, as their ability to penetrate the central nervous system, are suggested in the cases of meningoencephalitis. In pregnant females, long term bacteriostatic are advises till delivery. After delivery, doxycycline with hydroxychloroquine for 1 year is advised to given to the patients (Peng et al. 2023).

2.15. SALMONELLOSIS

Salmonellosis is zoonotic disease caused by bacteria of the genus Salmonella belongs to the family Enterobacteriaceae. Salmonella is the major cause of intestinal infection and it is present worldwide. It is the major problem in public and animal health. Salmonellosis is mainly characterized by headache, fever, malaise, vomiting, nausea, diarrhea and cramps. Although the infection can be an asymptomatic in some cases. It can occur in many forms of syndrome like gastroenteritis, bacteremia, enteric fever etc. Salmonella has more than 2000 serotypes but only 10-12 serotypes are involved in disease. Severity of infection depends upon the serotype and can be severe when the patient is immune deficient. Contaminated food has a major role in spreading the disease (Kuria 2023).

2.16. HOST SPECTRUM

Salmonella has a broad range of spectrum and includes cattle, horses, sheep, goat, cat, dogs, pigs and humans (de Silva et al. 2023).

2.17. CHARACTERISTICS OF SALMONELLA

Non spore forming
Rod shape
Motile (peritrichous flagella)
Oxidase test -ve
Gram negative
Have 2000+ serotypes
Facultative anaerobes (Kuria 2023)
Table 3 highlights the clinical features due to various Salmonella species.

Table 3: Clinical features of various Salmonella species

Features	*S. typhi*	Other species of Salmonella
Diarrhea	Absent	Present
Chronic Carrier	Present	May be present
Production of H2S	Present	Present
Fermentation of lactose	Absent	Absent
Reservoir host	Humans	Animals
Availability of vaccine	Present	Absent

2.18. TYPES OF SALMONELLOSIS

Salmonellosis can be broadly classified into two categories:

2.18.1. NON TYPHOIDAL SALMONELLOSIS (NTS)

This type of salmonellosis is food-borne and is caused by many serotypes of Salmonella (excluding Salmonella typhi). It is the major cause of a gastroenteritis in animals. It also produces enterocolitis in horses (Peter et al. 2023). Mainly spread by contaminated food. It is a self-limiting disease and animals are the main reservoir. Severity of infection depends on the serotype/serovar involved.

2.18.2. TYPHOIDAL SALMONELLOSIS

This type of salmonellosis is caused by bacteria Salmonella typhi. It is mainly transmitted by feco-oral route. It is the severe form of salmonellosis and mortality is high. It is characterized by fever, headache, nausea, cramps, vomiting and diarrhea. Generally, animals are not reservoir (Cho et al. 2023).

2.19. PATHOGENESIS

Asymptomatic carrier state, enteric fever, gastroenteritis, focal infection and septicemia are the several syndromes caused by Salmonella. The type of syndrome depends on the type of serovar involved, for example, enteric fever is produced by *S. typhi* and paratyphoid-A while septicemia is produced by Salmonella choleraesuis. But in rare cases any type of syndrome can be produced by any serovar being involved. Generally, infants, adult (over 50 years) and immunodeficient patients are at risk.

Salmonella can spread from person to person and is usually brought into the body through contaminated food (Dietrich et al. 2023). Pathogenesis depends on some virulence factors, which are:

- The capacity of bacteria to occupy cells
- A fully formed lipopolysaccharide coat
- The capacity of bacteria to divide intracellularly
- Production of toxins.

After being ingested, the bacteria settled in the colon and the ileum, occupy the epithelium and divide within the lymphoid follicles and epithelium. Bacteria binds to the specific receptors present on the epithelial cells and invasion started in which the ruffling of enterocyte membrane occurs resulting in pinocytosis of the bacteria. The bacteria divide intracellularly, multiply throughout the entire body via systemic circulation, then ascend through the reticuloendothelial system.

Most bacteria cause an acute inflammatory response after colonizing the intestines, which leads to ulceration. They may release cytotoxins that prevent protein synthesis. Due to inflammatory response, symptoms like diarrhea, abdominal pain, chills, fever and leukocytosis will produce. Feces may also contain blood, mucus and polymorphonuclear leukocytes (Parija 2023b).

2.20. EPIDEMIOLOGY

Non typhoidal salmonellosis is mainly transmitted by the food which is contaminated as a salmonellosis is a zoonotic disease and has a vast majority of a reservoir. Domestic and wild animals, pigs, turkeys and chickens are the common reservoir of NTS. Animal products are the main route of transmission which are not properly cooked and bacteria survivability increases in these products.

Typhoidal salmonellosis lack animal reservoir and mainly transmitted from person to person. Contaminated water and human faces are the major route of transmission. Plasmid DNA fingerprinting and Pulsed field gel electrophoresis are the main tools for studying and tracing the outbreaks of salmonellosis.

Asymptomatic carrier state and increasing antibiotic resistance are the two main factors which have epidemiological significance in both type of salmonellosis (de Silva et al. 2023).

2.21. DISEASE IN CATTLE

It is the major disease of cattle caused by serotype *S. Dublin* and *S. typhimurium*. These bacteria enter the body through ingestion and causes diarrhea and acute enteritis (*S. Typhimurium*) while systemic

infections and abortions are caused by *S. Dublin*. After getting entry into the body, there will be bacteremia and infection spread to lungs, liver, lymph nodes and spleen of the animal. Infection gets entry into the placentomes and causes abortion. Death may also occur during the infection.
The main clinical signs include severe diarrhea, fever (above 40 °C), dysentery, enteritis and abortion (in late pregnancy) (Senbeta 2023). Diagnosis is mainly based on the clinical signs and isolation of the organism from various discharges of the animal. Serological testing can also be performed.

2.22. DISEASE IN HORSES

The main causative agents of Salmonellosis are *S. bongori* and *S. enterica*. These species have more than 2400 serotypes which can be differentiated by O and H antigens. It is the main cause of colitis and diarrhea in horses. There are three forms of salmonellosis which are identified in horses:
1- The first type is subclinical carrier in which the animal may or may not be shedding the bacteria but has the ability to spread the infection to the other animals through feed, water or by direct contact. Given that the bacteria are intermittently and infrequently shed in the feaces, multiple cultures and PCR assays may be required to detect the carriers. If under stress, the carrier might get sick.
2- The second type is a mild clinical course which is characterized by fever, depression, soft feaces (not watery) and anorexia. CBC may show absolute neutropenia. This type is self-limiting and lasts for 4-5 days.
3- The third type is expressed as a severe clinical form which features abdominal pain, anorexia, depression and neutropenia. Diarrhea has a characteristic foul smell. Dehydration and electrolyte losses occur rapidly. Signs of hypovolemic shock and sepsis also develop. There may be colonic inflammation, gas distention, abdominal discomfort and infarction (Mair and Sherlock 2023).

2.23. DISEASE IN POULTRY

The main causative agents are:
- *S. Gallinarum*, *S. Pullorum* (non-motile)
- *S. Paratyphoid* (motile)

These agents have worldwide distribution. *S. Paratyphoid* is of significant importance because it can spread through contaminated poultry meat. Turkeys and chicken are the excellent hosts for *S. Gallinarum* and *S. Pullorum* while *S. Paratyphoid* can be transmitted to all the animals (Mair and Sherlock 2023).

2.23.1. PULLORUM DISEASE

The causative agent is *S. Pullorum*. In the incubator, you might see chicks that hatched from infected eggs, sick or even dead chicks. Disease goes undetected for 5-10 days. Excreta of infected birds may be greenish brown or white in color. Without any obvious signs, the infection persists within the flocks for a long time. Reduction in egg production, fertility and hatchability may occur. The main clinical signs are depression, inappetence, ruffled feathers, white diarrhea, closed eyes, loud chirping, gasping, rent pasting and lameness. Upon postmortem splenomegaly, urate crystals and grey nodules in heart and lungs may also be seen (Lublin and Farnoushi 2023).

2.23.2. FOWL TYPHOID

The causative agent of fowl typhoid is *S. Gallinarum*. Symptoms are same as that of pullorum disease. The main clinical signs are inappetence, dejection, yellow diarrhea and thirst etc. Upon postmortem there may be anemia, enlarged liver and enteritis (Nehra et al. 2023).

2.23.3. PARATYPHOID INFECTIONS

S. Montevideo, *S. Derby* and *S. anatum* are the common isolates found in Paratyphoid infections. Morbidity is high but mortality is low. Clinical signs are diarrhea, ruffled feathers, loss of appetite and dejection. Signs may be mild or absent. Upon post mortem there may be enteritis, pericarditis, unabsorbed yolk and dehydration (Nehra et al. 2023).

2.24. DISEASE IN HUMANS

In humans, three forms of disease have been recognized:
1- Septicemia
2- Enterocolitis
3- Typhoid fever (de Silva et al. 2023)

2.25. LABORATORY DIAGNOSIS

The organism can be isolated from the fecal sample in and enterocolitis while blood sample is required to isolate the bacteria in enteric fever. In case of bone marrow, the result of culture is often positive. On EMB and McConkey agar, the bacteria form colorless colonies. Salmonella forms gas and H2S on TSI with the exception of a *S. Typhi* which does not produce gas. Serological test can also be performed to identify these bacteria (Kuria 2023).

2.26. TREATMENT

Ciprofloxacin and ceftriaxone are the drugs of choice in salmonellosis. For the chronic carriers of S. Typhi, ampicillin cam be given.
Ampicillin and potentiated sulfonamides can be given in ruminants.
Oxytetracycline + neomycin (combined therapy) is given in poultry.
In horses' colloids, crystalloid fluids and various antimicrobials can be given.
In dog's chloramphenicol, fluoroquinolones and trimethoprim-sulphonamide is recommended.
Various vaccines are available for the prevention of salmonellosis (Kuria 2023).
Fig. 1 highlights various diseases along with clinical symptoms that are spread by mastitic milk of cattle.

3. CONCLUSION

Mastitis is the inflammation of udder or mammary glands caused by invasion of bacteria after any injury. Intake of this milk leads to the occurrence of many zoonotic diseases like brucellosis, mycoplasmas, tuberculosis, leptospirosis, listeriosis, salmonellosis and Q fever etc. Bovine tuberculosis is caused by *Mycobactrium bovis*. Clinical signs and symptoms include gross lesions in respiratory tract and associated lymph nodes. Listeriosis is cause by *Listeria monocytogenes*. It results in sepsis and meningitis, meningoencephalitis, rhombencephalitis in immunocompromised patients and fetal infection in pregnant women. It also causes gastroenteritis even in healthy individuals. This disease effect CNS of both animal and human. Q fever is caused by *Coxiella burnetti*. Human get Q fever by inhalation from birth products of affected animal. Clinical signs and symptoms in human in chronic cases include endocarditis and neurological signs especially in immune compromised person. In acute cases of Q fever in human fever, fatigue, headache, pneumonia and influenza like symptoms are observed. In pregnant female abortions, intrauterine fetal death and premature birth and low weight in newborn

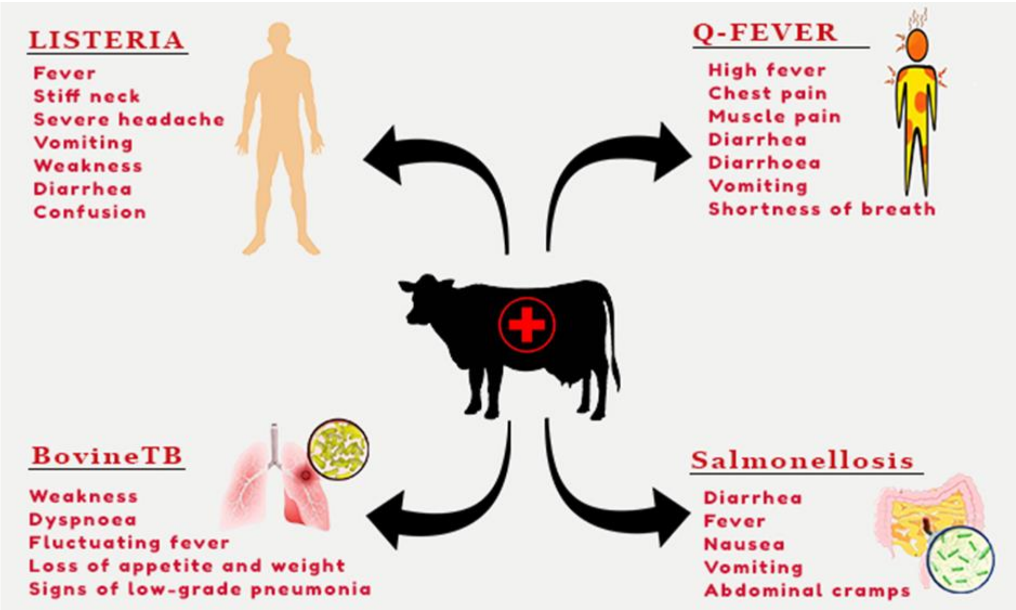

Fig. 1: Diseases spread by mastitic cattle milk

babies may result in Q fever. Salmonellosis mainly cause acute foodborne bacterial gastroenteritis. These diseases can be controlled by taking properly cooked meat and pasteurized milk. Various vaccines can also be used to control these diseases. Different drugs are also effective against these diseases.

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