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Review Article

BACTERIAL DISEASES OF LIVESTOCK ANIMALS AND THEIR IMPACT ON HUMAN HEALTH

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ABSTRACT

Recently, the whole world is facing the problem of infectious diseases related to animals that pose significant threats to human health. In other words, humans may acquire zoonotic infections through various routes, that is, food, water, etc. The transmission of certain bacterial diseases (through food and water) is one of the important causes of illness in both developing and developed countries. Most of the infectious pathogens that are normally reside in the intestinal tract of healthy animals and may transmit the disease through products (meat, milk or eggs) and fecal contamination of the environment. Normally, a minute amount of intestinal contents are released and contaminate milk during milking; carcass at slaughter and egg during laying. In general, risk associated with this type of contamination is somehow minimized where proper food hygiene is normally applied throughout the entire food chain from production, through processing to preparation at home. In this view, we provide some information about bacterial diseases of livestock animals and their effect or impact on human health.

Keywords: Animal, Diseases, Livestock, Intestinal, Food.

INTRODUCTION

Animal source foods (milk products) are the biggest contributor to foodborne diseases and their effect directly or indirectly to human health [1]. In general, bacterial diseases are transmitted from livestock products and kill more people each year as compared to HIV or malaria [1,2]. In general, animal diseases showed two basic types of problem for human's, that is, economic risks (loss of productivity, market disruption, livelihood risks, etc.) and human health risks (pandemic and endemic disease including foodborne illnesses). In short, sick animal produces less meat, less milk, or fewer eggs. It provides less draught power and poorer-quality food including fiber as well [1-3]. In economic terms, output rate and net profit will be declined. In traditional systems, the costs of animal diseases related to veterinary services are often not affordable [3,4].

Although, several diseases can be transmitted through food or food-borne diseases that are considered as a specific group. Organisms such as *Brucella, Campylobacter, Escherichia coli* O157: H7, *Salmonella* (particularly *Salmonella* Enteritidis and *Salmonella* typhimurium), etc., are included as food-borne threats that are responsible for causing illness in millions of people worldwide every year [5,6]. This review discusses some animal diseases (bacterial) that may affect human health and the risks of contracting the disease through the food chain.

BRUCELLOSIS

One of zoonotic infections, i.e., *Brucellosis* (genus *Brucella,* Gram-negative) is generally caused through ingestion of unpasteurized milk and uncooked meat products from infected or highly contaminated animals or close contact with their secretions [7,8]. Till now, only four species of *Brucella* are reported and infected different species, i.e., *Brucella abortus* (cattle's), *Brucella canis* (dogs), *Brucella melitensis* (goats and sheep), and *Brucella suis* (pigs). This disease is also reported in human as well and the most common symptoms that are observed, i.e., joint and muscle pain including profuse sweating. *Brucella* species are included under facultative intracellular microbes that persist and multiply within phagocytic cells of the host. In general, *Brucella* organisms ultimately become concealed within blood monocytes and tissue macrophages of the reticuloendothelial system (i.e., lymph nodes, liver, spleen and bone marrow) [9,10]. This disease is recorded as one of the old diseases and called by different names, i.e., Mediterranean fever, Malta fever, gastric remittent fever, and undulant fever. Humans are included as accidental hosts, but brucellosis continues to be one of the major public health concerns worldwide and is the most common zoonotic infection (Fig. 1). In human, this disease mainly targets specific organs and showed some enlargement especially in case of liver, spleen, and/or lymph nodes. However, this disease is caused through infection with a *Brucella* strain and the treatment including diagnosis of this disease must be supported by laboratory tests which indicate the presence of particular organism [11].

Brucellosis, disease included under systemic infection that can involve or attack any organ or tissue of the body. Most of the clinical symptoms that are appeared and related to specific organ which predominates the disease and is termed as localized. The most familiar example of localization that involves the organs of reticuloendothelial system. Although humoral antibodies played a crucial role in resistance to infection the principal mechanism of recovery from brucellosis disease pertaining to Fig. 1. *Brucellosis* required cell-mediated immunity [12]. In other words, cellular immunity involves T cells especially cytotoxic T lymphocytes which energizing the macrophages for stimulating their antimicrobial activity, through the release of T helper-1 cytokines (e.g., interferon gamma and tumor necrosis factor) [11,12].

Lot of evidence are reported related to diagnosis of this human disease in blood or tissue samples:

a. Identification and isolation of *Brucella* species
b. Demonstrated the presence of genetic material in sample analysis (blood or tissue sample) through polymerase chain reaction (PCR)
c. Demonstrated through the serological method of *Brucella* antigen.
d. Demonstration of rising antibody (IgG and its subtypes, i.e., IgG1 and IgG2) titer in any serological test for *Brucellosis* in the absence of exposure to any known source of cross-reacting antigens.
e. Demonstration of high sustained IgG antibody titer in the agglutination (antigen/antibody complexes), complement fixation or ELISA (antigen/antibody estimation) tests with standardized antigens.

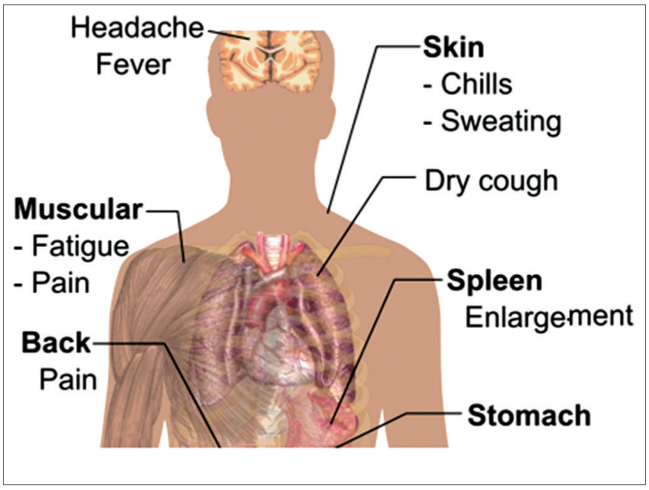

Fig. 1: *Brucellosis*

Susceptibility to *Brucellosis* disease in humans depends on various factors including immune system status, routes of infection including the size of the inoculum or substance and to some extent, the species of *Brucella*. In general, *Brucellosis* strains, especially *B. melitensis,* and *B. suis* are more virulent for humans as compared to *B. abortus* and *B. canis*, but serious complications will also be reported in some species of *Brucellosis* [7-11]. The most common and observable routes of infection, i.e., direct inoculation through cuts or abrasions in the skin, inoculation through conjunctival sac of eyes, inhalation of infectious aerosols and ingestion of infectious unpasteurized milk from dairy products. Out of these, blood transfusion, tissue transplantation, and sexual transmission are rare routes of infection [8-10].

In short, *Brucella* bacteria is more commonly and reported in livestock animals as compared to human. Eating or drinking affected dairy products is the most common method of transmission, but can also be transmitted by affected animals to people according to centers for disease control. These animals, especially cow, goat, buffalo, pig, etc., are most commonly affected animals. In general, the presence of moisture in the atmosphere and unhygienic conditions can expedite spread of the disease. The most commonly observed symptoms appeared in human after suffering with *Brucellosis* disease, i.e., fever, joint and back pain, headache, inflammation occurring in lymphoid organ, especially spleen, etc. Ensuring proper hygiene in cattle sheds is another way to prevent the burden of infection in cattle [7-11].

CAMPYLOBACTERIOSIS

This is considered to be one of the most commonly bacterial causes of human gastroenteritis. This disease is reported mostly in children and very few cases in adults [13,14]. This disease could be due to poor hygiene, sanitation and proximity with animals. Although, infection rate of this disease in children will decline with age [13-16]. As per the literature, this infection showed serious long-term consequences including peripheral neuropathies and also reported various syndromes as well, e.g., Guillain–Barre syndrome (GBS, an autoimmune disorder of the peripheral nervous system) and Miller Fisher syndrome and functional bowel diseases such as irritable bowel syndrome. In the US, each year more than 2.5 million people are infected by this infection, i.e., *Campylobacter* [14-18].

Two species of campylobacteriosis are reported (i.e., *Campylobacter jejuni* and *Campylobacter coli*) but isolation rate of *C. jejuni* is much higher as compared to *C. coli*. In addition, *Campylobacter upsaliensis, Campylobacter concisus* and aerotolerant *Campylobacters* (*Arcobacter*) may also show some pathogenic importance [13-15]. However, there is lacking for diagnosis capacities or abilities to find out their distribution in developing countries. The main sources of human infections are:

a. Environmental contamination - Wild birds and domestic animal species are one of the reservoirs for *Campylobacter* species and shedding their bacteria from these species and causes contamination of the environment. Two species, i.e., *C. jejuni* and *C. coli* are isolated and reported in chickens/goats/sheep/pigs. Most of the strains are identified and isolated from human, and poultry animals, especially chickens were phenotypically and genotypically correlated and confirmed that chickens are included as one of the most important sources of human campylobacteriosis. Extensive epidemiologic studies and lot of research work have been carried out pertaining to identify the main sources of contamination and routes of transmission to humans to facilitate control efforts.
b. Food - Generally food is contaminated because of various bacteria that are reported but this bacterium, i.e., *Campylobacter* is one of the important potential sources of infection in humans. In most of the developing countries, risk factors are mutually associated with food products include occupational exposure to farm animals, consumption of raw milk including milk products and unhygienic food preparation practices.

The incident rate of human campylobacteriosis disease is enormously increasing worldwide [13-15]. Lot of research work is already done or still under progress pertaining to control the burden of this disease. In short, public health awareness about these problems are needed and strengthened diagnostic facilities for campylobacteriosis.

E. COLI O157:H7 (*E. COLI*) INFECTION

E. coli (Gram-negative bacteria), firstly identified as human pathogen and is generally reported in the intestines of all humans and most animals (Fig. 2). Pathogenic *E. coli* strains are divided into several pathotypes, and these are associated with diarrhea and collectively called as diarrheagenic *E. coli* [19,20]. These pathotypes are,

- Shiga-toxin-producing *E. coli* also called as verocytotoxin producing *E. coli* or enterohemorrhagic *E. coli* is one of the one most common association with foodborne outbreaks
- Enterotoxigenic, enteropathogenic, and enteroaggregative *E. coli*
- Enteroinvasive and diffusely adherent *E. coli*.

E. coli, naturally occurring and reported in digestive tracts and this bacterium is required as well as needed to keep human and animals healthy [19]. Number of different strains (>100) are reported, and these strains are mostly beneficial or somehow harmless to animals including humans. Some of the strains showed some hazardous effect, e.g., *E. coli* O157:H7 is normally shed in the manure of many warm-blooded animals (e.g., deer, geese, dogs, and cattle), but it is hazardous for humans, especially immunocompromised people or weakened immune system because it produces lot of toxin that can cause severe illness [19,20]. Number of routes for causing the disease to humans. These are,

- Consuming undercooked or half-cooked meats that were contaminated or infected at slaughter or during preparation
- Consuming fresh fruits/vegetables irrigated or washed/cleaned with contaminated water
- Consuming water from contaminated water sources (lakes, rivers, ponds, etc.) that are not maintained properly.

One of the diseases, hemorrhagic colitis, is caused through *E. coli* O157:H7 and is characterized through severe cramping (abdominal pain), diarrhea, vomiting, and fever. For treatment purpose, antibiotic treatment does not be able to reduce the burden of the pathogen that are responsible for causing illness or diminished the development of hemolytic uremic syndrome [21-23]. Lot of explanations are given for lack of benefit for antibiotic treatment are,

- Elimination of competing bowel flora by the antibiotic giving a competitive advantage to *E. coli* O157:H7
- Lysis of *E. coli* O157 leading to enhanced synthesis and release of verotoxin.

E. coli serotype (expressing 0-antigen 157 and the H-antigen 7, i.e., O157:H7) that belongs to enterohemorrhagic *E. coli* group [21-23]. This group of bacteria contained more than one virulence factors, i.e.,

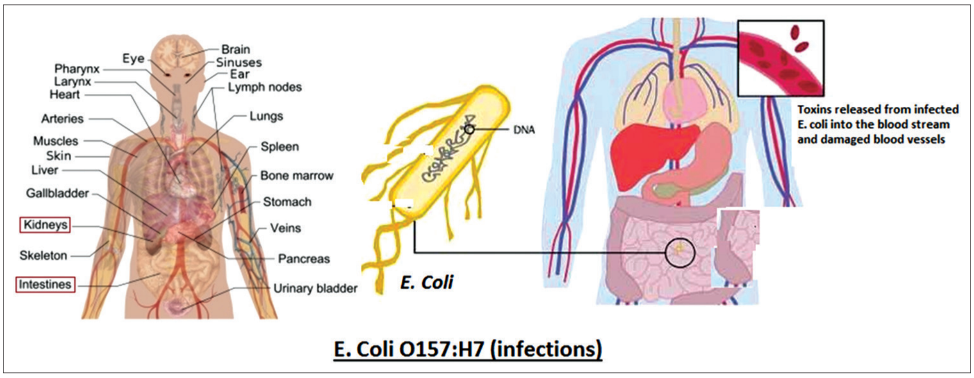

Fig. 2: *Escherichia coli* O157:H7 (infections)

- Shiga-like toxin(s) (SLT also known as verotoxins or VT)
- Adherence factors (organism to attach to and colonize intestinal mucosal cells)
- Enterohemolysin (the majority of hemolytic uremic syndrome - associated strains contained plasmid, 60-MDa which encodes the production and synthesis of enterohemolysin).
- Another virulence marker, i.e., chromosomal eae gene which encodes its synthesis and production of intimin, an adherence factor.
- Most importantly, use of DNA probes for detecting various genes encoding for virulence factors, particularly, verotoxins production, which is the most sensitive enterohemorrhagic *E. coli* testing methods.

The presence of this disease, especially *E. coli* 0157:H7 is confirmed through stool culture since the bacteria usually live in human digestive system [19-23]. After stool culture, analysis of this sample is compared with standard *E. coli* 0157:H7 that were cultured in the laboratory. Lot of commercial kits available related to this test e.g. Bio-Rad RAPID *E. coli* O157:H7 kit can be used in the research lab.

LISTERIOSIS

Listeriosis infection is due to *Listeria monocytogenes* (Gram-positive, family *Listeriaceae*; 13 serotypes; facultative intracellular pathogen) and these are generally found in a large variety of foods, soil, water effluents and also reported in the faeces of humans and animals [24]. According to the literature, all serotypes of this bacterium are considered virulent whereas serotypes (4b, 1/2b, and 1/2a) are responsible for causing disease to both animal and human. The most familiar example is *Listeria ivanovii* (also called as *Listeria bulgarica* or serotype 5 of *Listeria monocytogenes*) which is associated with abortions (sheep and cows). Rare infections with *L. ivanovii* and *Listeria seeligeri* are also reported in humans. In contrast, other species such as *Listeria innocua, Listeria welshimeri* and *Listeria grayi* have not been associated with human disease [24-26]. The most significant feature of *Listeria* species is that they can multiply at high salt concentration and also occurred in acidic condition as well. The major symptoms reported in human, i.e., fever, muscle aches, encephalitis, diarrhea, other gastrointestinal symptoms, etc., which is suffering from this bacterial disease. However, the diagnosis of this disease should be performed on the basis of clinical symptoms and presence of bacteria in smear from blood, cerebrospinal fluid, vaginal secretions, etc. in addition, PCR are also applied for diagnosis of listeriosis in humans. During pregnancy, blood cultures including placental culture are one of the most reliable ways to find out if symptoms will appear or due to listeriosis [27,28].

Lot of research work is carried out pertaining to reduce the burden of this bacterial disease, i.e., listeria species [24-28]. A number of precautions were taken to prevent disease, i.e., listeriosis and also helped to prevent other foodborne illnesses, such as salmonellosis. The major points are,

- Wash hands, knives and cutting boards with soap and water after handling and processing uncooked foods
- Avoid unpasteurized milk or its products made from unpasteurized milk
- Wash raw vegetables properly with clean water before eating
- Keep uncooked meats separate from rest of the vegetables including cooked foods. Consume perishable food as soon as possible.

ORF (SORE MOUTH INFECTION, CONTAGIOUS ECTHYMA)

One of zoonotic diseases, i.e., contagious ecthyma (orf or sore mouth) is most common disease in human which is closely associated with animals (sheep and goats). The major population that suffering from this disease, i.e., herders, sheep-shearers, veterinarians, butchers, etc. The incubation period of this disease observed in humans is 3-7 days [29,30]. Most of the infected people develop a solitary lesion, but generalized infections have also been reported. First, lesion will appear, and papule (red or blue in color) is so small where the virus will penetrate and effected fingers, hand or other exposed part of the body. Thereafter, papule start developing to transform into hemorrhagic pustule or bulla which may contained central crust and bleeds easily. In later stages, these lesions were developed into small nodule, which may weep fluid and is sometimes covered by a thin crust. It eventually becomes covered by a thick crust. The skin lesions may be accompanied by a low-grade fever that usually lasts only a few days, or by mild lymphadenopathy [29-32].

In some cases, large lesions reported in those people who are immunosuppressed, for example, atopic dermatitis. Rare cases are also reported which involves eye as well as a generalized vesiculopapular rash on the skin and mucosa. Sometimes, lesion will disappeared in 3 to 6 weeks without scarring. No deaths have been reported in this disease and this transmission of disease from human to human is non-existent or very rare [29-32].

Q FEVER

Q fever, zoonotic disease caused by *Coxiella burnetii* and reported as an obligate Gram-negative intracellular bacterium. Transmission of this disease to humans through inhalation of aerosols from contaminated soil or animal waste. Other modes of transmission, i.e., tick bites, ingestion of unpasteurized milk or dairy products [33,34]. The main reservoir for causing this disease, i.e., cattle, sheep and goat. The major symptoms that are observed in acute Q fever, i.e., high fevers (up to 104-105°F); a severe headache; sweats; cough; nausea; vomiting; diarrhea; abdominal pain; chest pain, etc. In addition, serious complications may also report, e.g., pneumonia, granulomatous hepatitis (inflammation of the liver), myocarditis and central nervous system complications [35,36].

C. burnetii has capability to survive on its own and persist for long periods of time in the host after infection. However, the majority of peoples that are recovered completely with acute Q fever, post-Q fever fatigue syndrome has been reported in 10-25% of patients. This syndrome is characterized by constant fatigue, night sweats, severe headaches, photophobia (eye sensitivity to light), pain in muscles and joints, mood changes, and difficulty sleeping. As per the treatment, antibiotics especially doxycycline is most effective at preventing severe complications [32-36].

SALMONELLOSIS

Salmonella (food-borne disease; Gram-negative, motile bacilli; family *Enterobacteriaceae*) isolated from feces, lungs, and liver of slaughtered goat and prevalence of 0.7% has been recorded. Different kinds of these bacteria, i.e., *Salmonella* serotype typhimurium and *Salmonella* serotype enteritidis are the most common types [37,38]. This disease is transmitted through contaminated food and characterized clinically by septicemia and enteritis. In general, poultry animals, milk products including eggs are most often infected with *Salmonella* and also vegetables may also be contaminated. Salmonellosis disease is more commonly observed in children's, and number of cases related to this disease is still more in summer season. Not all the food related to animals which interact with *Salmonella* and develop salmonellosis, rather such animals become carriers, along with the recovered ones from the disease and such animals are a constant source of zoonosis. Recently, the most common zoonotic bacterial diseases of adult goats characterized by diarrhea and most frequent one is salmonellosis [37-40].

SUMMARY

Diseases will occur because of an interaction between the disease, host and environment. The severity of disease that depends on the level of activity of the pathogen, the level of resistance of the host and the effect of the environment. In general, numerous zoonotic diseases that can be transferred from livestock products to human beings. In other words, these zoonotic diseases showed severe symptoms to human and definitely it will concern to farmers and their families. While some of the zoonotic diseases are very rare, its potential for devastating outcomes makes it necessary to take precautions for these diseases seriously. Luckily, many of the precautions are taken to prevent these diseases.

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