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Review on Camel Brucellosis and Its Public Health Significance

Adem Edao and Jemal Adem

College of Veterinary Medicine, Haramaya University, P.O. Box: 138, Diredawa, Ethiopia

Abstract: Dromedary, one-humped camels (*Camelus dromedaries*) are an almost exclusively domesticated species as both beasts of burden and production animals for meat and milk. Camels still play an important role in providing food security in several developing countries. The chief role of the camel relates directly to its remarkable adaptation to extremely harsh conditions. However, these contributions of camels to the human welfare of developing countries are generally obscured by several factors, among which disease is the basic one as brucellosis which has zoonotic importance, thereby diseased camels can infect humans chiefly via milk. Camels were formerly considered resistant to most of the diseases commonly affecting livestock, but as more research was conducted, camels were found to be susceptible to a large number of pathogenic agents. Brucellosis is one of the common bacterial diseases of a camel which is caused by genus Brucella resulting in substantial loss of production. In dromedary camels, brucellosis can be caused by *B. abortus*; *B. melitensis* and *B. ovis* which results in significant loss of productivity through late first calving age, long calving interval time, low herd fertility and comparatively low milk production. The disease is found widespread in camel rearing regions of the world whereas age; sex; management and husbandry practice are considered as a major risk factor. The prevalence of camel brucellosis which was reported from different pastoral areas of Ethiopia is quite varying. Additionally; research conducted on camel brucellosis is scarce and is limited only to serological study with no confirmed isolation of Brucella bacteria. In humans, brucellosis is a debilitating disease with nonspecific symptoms and infertility being the common sequelae. The disease is transmitted by contact with infected camel; consumption of unpasteurized dairy products and undercooked meat. To treat brucellosis in humans, several conventional antibiotics are used in clinics and can also be controlled through milk pasteurization and hygenic measures coupled with effective disease surveillance and animal movement control. In spite of its vital importance, limited studies are available of brucellosis in camels in Ethiopia.

Key words: Brucellosis · Camel · Ethiopia · Zoonosis · Transmission

INRODUCTION

Camelids belong to the family Camelidae, order Artiodactyla and suborder Tylopoda having pad-footed animals [1]. The genus Camelus belong to the family Camelidae with two species comprising one-humped dromedary (*Camelus dromedaries* or Arabian camel) and two-humped bactrian (*Camelus bactrianus*) camels that are found in semi-dry and dry areas of central, East and western Asia, sub-Saharan and North African countries as well as in near and middle East regions [2]. The camel's ability to survive and produce under harsh environmental conditions has made it possible to use marginal and desertified ecosystems; and over the centuries, the camel has been a symbol of stability for the pastoralists in the arid zones of the world [3]. Although camels were considered previously, as resistant to many disease causing agents, it has been proved that they are susceptible to the common disease causing pathogens [4] due to severe stress conditions [5].

Brucellosis is a significant neglected zoonotic infection in the majority of camel-rearing regions that was reported in camels as early as 1931 [6]. Camel brucellosis is a disease caused by *Brucella mellitensis* and *B. abortus* with considerable public health and economic importance to as owners consume raw milk [7]. Based on the reports of different scholars, *B. abortus* and *B. melitensis* are the most frequently isolated Brucella spp from milk, aborted fetus and vaginal swabs of diseased camels. Even though camels are not known to be the

Corresponding Author: Adem Edao (DVM), Department of Veterinary Public Health, College of Veterinary Medicine, Haramaya University, P.O. Box: 138, Diredawa, Ethiopia.

primary hosts of Brucella, they are susceptible to both *B. abortus* and *B. melitensis* and consequently, the prevalence depends upon the infection rate in primary hosts being in contact with them [8]. Camel brucellosis is caused by Gram-negative coccobacilli bacteria of the genus Brucella and is characterized by lesions of lymph nodes and joint capsules, orchitis and epididymitis, inflammation of the uterus, abortion and reduced fertility. Also, many infected camels are silent carriers of brucellosis [9].

The prevalence estimation of brucellosis in camel is difficult because of a few clinical signs in comparison with other livestock [7]. Consumption of Brucella infected food e.g. milk and meat from camels has led to a high number of human brucellosis cases and is a serious public health issue. The situation is even more grave as farmers from rural areas think that raw camel milk has a healing effect on the digestive system [10]. Accordingly, the contact of camel with the primary hosts of the disease measures the infection and prevalence rate in the camel. Consumption of milk and meat from diseased camel, especially in nomadic areas where people believe that utilization of raw milk is very effective in the cure for ailments, leads to human brucellosis [11]. Poor management practices and mixing of camels with other species of livestock as well as unrestricted movement of camels were proposed to be the reasons for the prevalence of the disease [12].

The disease spread when people consume unpasteurized contaminated milk and contact with infected tissues and discharge including consumption of raw liver. Brucellosis is characterized by none specific symptoms such fever, chills, headache, pain, fatigue, dementia and arthritis, which occur within 2-3 weeks of inoculation [13]. Based on the nature of the disease and ease of transmission, the pastoral societies are at great risk due to their close physical contact with susceptible animals [14]. For accurate diagnosis of camel brucellosis, serological tests like RBPT are cheap and easy for herd based screening of animals with high sensitivity and low specificity [15] whereas tests like ELISA and CFT are used for confirmatory test.

Generally, despite the presence of large population of camel in the pastoral areas of Ethiopia [16], reports of camel brucellosis and studies of management practices are limited. Additionally, even if the disease is one of the oldest recognized diseases of mankind and get controlled in most developed countries [17] only little effort has being made to control this disease in developing countries specially in Ethiopia due to the nature of diseases. Therefore objectives this review is:

To overview the distribution, etiology, pathogenesis, diagnosis, treatment, zoonotic importance and current status of camel brucellosis in Ethiopia.

Camel Brucellosis

Etiology: The genus of *Brucella* are subdivided into six species categorized by antigenic variation and primary preferred host and these include *B. abortus*, *B. melitensis, B. suis, B. ovis, B. canis* and *B. neotomae* [18]. The ability of genus *Brucella* to replicate and persist in host cells is directly associated with its capacity to cause persistent disease and to circumvent innate and adaptive immunity. Camels can be infected by either of the main species of the genus *Brucella* (*Brucella abortus* and *Brucella melitensis*). *B. abortus* was the main cause of brucellosis in camels while *B. melitensis* as the agent of camel brucellosis [19]. Brucella are Gram-negative facultative intracellular cocco-bacilli that are non-encapsulated, non-spore forming and non-motile belonging to the α-2 subdivision of the proteobacteria [20]. Certain strains of brucella bacteria need about 5% to 10% of CO_2 for growth. Brucella organisms grow slowly, but can be enhanced by using enriched media [21].

Ten Brucella species are currently recognized, including the better known six classical species comprised of *B. abortus* (biovars 1-6 and 9*), B. melitensis*, (biovars 1-3), *B. suis* (biovars 1-5), *B. ovis, B. canis* and *B. neotomae*. The more recently, identified new members brucella species include; *B. ceti* and *B. pinnipedialis*, *B. microti* (voles) and *B. inopinata* [22]. Brucella species are distinguished based host preference and phenotypic characteristics [23]. However, host preference is not absolute and most of the species of Brucella bacteria have been isolated in multiple different hosts [24].

Morphology and Growth Requirement of Brucella: Brucellae are coccobacilli or short rods, usually arranged singly but sometimes in pairs or small groups. The organisms are gram negative facultative intracellular parasites. Carbon dioxide is important elements for growth of *Brucella* organism, especially *B. abortus*; such organisms, which require carbon dioxide for their growth, are called capnophilic organisms. At PH < 4, *Brucella* agents do not have potential to survive [25].

Brucellas are very small faintly stained coccoid rods, with a microscopic appearance of fine sand. Primary culture of brucella reveals punctate, non-pigmented and non-hemolytic colonies. Colonies of smooth(S) brucella strain are raised, convex, circular, translucent and 0.5-1 mm in diameter [26] The colony morphology of brucella may become less convex and more opaque with

a dull, dry, yellowish, white granular appearance which is caused by dissociation of brucella from smooth to rough(R) forms [27].

Epidemiology of Camel Brucellosis in Ethiopia: Brucellosis is a worldwide bacterial zoonotic disease affecting both animals and humans. It causes serious human health hazards and economic loss [28]. Brucellosis in human is common in rural areas because farmers or pastoralists live in close contact with their animals and often consume fresh unpasteurized dairy products [29]. Camel milk is one of the most valuable food resources for nomads in Camel rearing regions and can contribute to a better income for pastoralists [30]. Camel milk possesses superior keeping quality to cows' milk due to its high contents of proteins that have inhibitory properties against bacteria. This makes raw camel milk a marketable commodity, even under conditions of high temperatures [3].

Brucellosis in human is common in rural and pastoral areas, because farmers or pastoralists live in close contact with their animals and often consume fresh unpasteurized dairy products. In addition pastoralist handle aborted cases with bare hand which main source of the disease in the area [31]. This variation in seroprevalence of camel brucellosis attributed to the difference in animal husbandry and management systems practiced by pastoral society [32]. In Ethiopia, pastoralists used to consume raw milk, which contributes to the transmission of this disease among human and animals. Above three-quarters of the pastoralists are practicing at least one activity considered to be risky for the transmission and widespread occurrence of zoonotic brucellosis and more than 75% of the animal owners do not know about zoonotic Camel brucellosis [33].

Risk Factors

Age: Age has been referred to as one of the intrinsic factors associated with brucellosis in animals. According to [34] report, brucellosis has traditionally been considered as a disease of adult animals since susceptibility increases after sexual maturity and pregnancy. This is due to the fact that, Brucella spp. presents tropism to the reproductive tract due to the production of erythritol sugar in the foetal tissues [35]. Long time contact with infected animals or with the environment also contributes to the higher prevalence of brucellosis in adults animals which are significantly seen in those herds without culling of positive animal [36].

Sex: The influence of sex in the prevalence of brucellosis has been studied in domestic and wild animals [37]. In camels, females are more susceptible to brucellosis than male. This relatively higher susceptibility of female camels could be due to the fact that they have more physiological stresses than the males [37]. According to [38], male animals are less susceptible to Brucella infection due to the absence of erythritol sugar which is found in the uterus. Also female camels are kept longer in herds for breeding purposes than male camels which are fattened and sold off except for a few that are kept to service the females, for haulage, transport and other such purposes [39].

Environmental and Management Risk Factors: Brucellosis can occur in any season of a year. However, February to July is the season of the year when peak epidemics of brucellosis occurs and is closely related to the months associated with delivery and abortion in animals [40]. Uncontrolled trade of clinically inconspicuous animals leads to high individual animal and herd prevalence which do not only pose a continuous risk for human infection, but also increase the spread of infection through several risk factors. Habitat, herd size, cohabitation with other ruminants and contact with other camels, leads to an inter-camel cycle of the disease [41].

Further risk factors are the increase in species composition at household level and the wet season. Due to this, camels appear to become infected via spill-over from small ruminants and cattle. This observation is supported by the fact that all *Brucella* spp. and biovars infecting other ruminants have also been isolated from camels. The camel kept mixed with other ruminant species were have a high chance to expose to brucellosis than those reared alone [42]. The epidemiology of camel brucellosis can also be influenced by management system where the higher prevalence of the disease was recorded in camels kept under intensive management system [43].

Pathogen Risk Factors: *B. abortus* and *B.melitensis* are the etiological agents of camel brucellosis and responsible for an economically important cause of abortions. *B. abortus* also affects other species such as bison, buffalo or elks representing an important risk for the maintenance of the agent in the animal population with special importance in areas where wildlife and domestic animals live together. Moreover, infections in wildlife can hinder eradication efforts in domestic animals. *B. abortus* is still a human pathogen and outbreaks arise from contact with infected animals and ingestion of contaminated dairy products represents an important risk of infection [44].

Transmission of Camel Brucellosis and Impact on Human Health: The primary shedding routes of Brucella organisms remain uterine fluids and placenta expelled from infected animals. Due to this, both domestic and wild animals can contract brucellosis through direct contact with infected animals and their excreta. Many placental mammals, including herbivores, participate in placentophagy, with camel as a noted exception, which may contribute to the spread of Brucella bacteria through wind. Although parturition in camels is generally occurred in a laying or standing position without extra help, they may deliver or abort on the pasture and the aborted material may spread over a wide area of the pasture by stray dogs and foxes. This play an important role for the transmission of the disease to other health animals [45]. On the other hand, a close contact between infected and susceptible camels in a herd promotes the spread of diseases. The camels share the same watering points and pastures with other livestock and so it is not surprising to find a higher incidence of the disease among camels [46]. Generally, Animals become infected through feed, water, colostrum, contaminated milk and, especially, by licking or sniffing at placentas and aborted fetuses.

In humans, the disease, which is often referred to as 'undulant fever' or 'Malta fever' is a serious public health problem. Human brucellosis remains one of the most common zoonotic diseases worldwide, with more than 500, 000 new cases annually. Infection prevalence in the animal reservoirs determines the incidence of human cases [47]. Brucella spp. are also potential agents of bioterrorism and are classified in group B (second-highest priority agent) of the Centers for Disease Control and Prevention (CDC) in the USA. *Brucella melitensis* and *B. abortus* are the two species most commonly found in human cases and *B. melitensi*s is responsible for the most serious infections. Human brucellosis is mainly an occupational disease and the main modes of transmission are contact through skin with animal tissues, blood, urine, vaginal discharge, aborted fetuses and, especially, placentas and by consuming raw milk and other unheated dairy products. Airborne infections occur in animal pens, stables, laboratories [48] and abattoirs.

In human, brucellosis is transmitted by contact with infected animal, consumption of unpasteurized dairy products and undercooked meat, drinking camel urine [49] including aerosol transmission. For instance, consumption of traditional delicacies such as raw liver can cause human infection [7]. In humans, the incubation period lasts from five to 60 days, but can also be longer. Clinical signs are not specific and can be acute or chronic [50]. Brucella infections in pregnant women in early pregnancy may lead to high rates of fetal loss (up to 40%) and infection in men can lead to orchitis and epididymitis. *Brucella melitensis* DNA persists in human blood for many years after infection despite appropriate treatment and apparent recovery [51]. Humans are at risk through consumption of unheated milk or through handling Brucella-positive animals [52]. Extreme care must be exercised when working with Brucella organisms in laboratories. It is estimated that up to 2% of all diagnosed brucellosis cases are laboratory-acquired infections, mainly through inhalation when handling diagnostic specimens [11].

Pathogenesis: Brucella organisms are pathogens that ultimate goal is to propagate in their preferred niche, the cell. The ability of Brucella spp. to cause disease requires a few critical steps during infection. Although the mechanisms that allow host cell invasion by *Brucella* spp. are not completely clear, internalization of *Brucella* into host cells requires cytoskeletal changes. *Brucella* spp. can invade epithelial cells of the host, allowing infection through mucosal surfaces: M cells in the intestine have been identified as a portal of entry for *Brucella* spp. [5]. Upon cell contact, the bacteria are internalized via receptor molecules by activating small GTPases of the Rho subfamily and by a moderate recruitment of actin filaments [6]. Interestingly, invasion through the digestive tract does not elicit any inflammatory response from the host and therefore, Brucella spp. invade silently or unnoticed by the innate immune system of the host [1]. Once *Brucella* spp. have invaded, usually through the digestive or respiratory tract, they move to regional lymph nodes and are capable of surviving intracellular within phagocytic or non-phagocytic host cells with the help of enzyme called cytochrome oxidase [1]. On the other hand, Acidification of the Brucella containing vacuole during early steps of infection is also required for intracellular survival since acidified environment induces changes in the profile of bacterial gene expression favoring intracellular survival [3].

So, the pathogenicity of *Brucella* is due to its ability to adapt to the environmental conditions encountered in its intracellular replicative niche including low levels of nutrients and oxygen, acidic pH and reactive oxygen intermediates [2]. Inside the cells, Brucella has the ability to interfere with intracellular trafficking, preventing fusion of the Brucella containing microphages(phagosomes) with lysosome markers and directing the vacuole toward a compartment that has rough endoplasmic reticulum (RER),

which is highly permissive to intracellular replication of Brucella [7]. Then, Brucella spp disseminate throughout the body and induces suppression of the transcription of pro inflammatory mediators in trophoblastic cells at very early stages of infection in female [53]. After an initial suppression of pro-inflammatory transcripts, Brucella bacteria induce expression of pro-inflammatory chemokines which finally results in abortion in female animals [54]. The outcome of Brucella infection depends on the animal species infected, age, immune status of the host, pregnancy status and the virulence and the number of invading organism. When the bacteria prevail over the host's defenses of susceptible pregnant animal; bacteremia often leads to the invasion of the uterus. Generally, Localization of Brucella bacteria within the female and male reproductive tracts accounts for the most common clinical signs of infection: abortion and male infertility [55].

Clinical Sign: Brucellosis is characterised by abortion and to a lesser extent by orchitis and infection of the accessory sex glands in males. According to various researchers, the clinical signs of brucellosis in breeding camelids are the same as those in bovines and small ruminants, although infection in breeding camelids causes fewer abortions than it does in bovines and small ruminants [56]. Infections may cause stillborn calves, retained placenta, fetal death and mummification and reduced milk yield. Also, delayed service age and fertility have been reported [57]. A retained placenta is rare in Camelidae. This may be a result of the difference in the placental attachment [58]. Camelids possess a placenta diffusa like the horse and not a cotyledonary placenta.

The clinical picture of brucellosis in camels can vary from asymptomatic to abortion [59]. According to various researchers, the clinical signs of brucellosis in breeding camels are the same as those in bovines and small ruminants, although infection in breeding camel causes fewer abortions than it does in bovines and small ruminants. Abortion in camel due to brucellosis usually occurs only once. Dams can develop ovario-bursal adhesions, hydrobursitis and granulomatous endometritis. Placental retention, infertility and delayed sexual maturity have also been reported [60]. Males may suffer from orchitis, infection of the accessory sex glands, arthritis accompanied by acute lameness [61]. Some authorities feel that the most significant result of infection may be premature birth. Brucellosis also causes fetal death and mummification and reduced milk yield. It was reported that delayed service age and fertility are also another complication associated with brucellosis. However, placental retention is rare in camel due to the difference in the placental attachment as they possess a diffuse like placenta [62].

Diagnosis: Establishment of adequate control programs against brucellosis in a population depends on the presumptive diagnosis of the infection. Brucellosis may be suspected based on clinical signs such as abortion, but confirmation can be made through serological tests. Since 1897, a considerable number of serological tests have been developed. A number of these tests were modified in various ways to increase performance [56]. Serological tests offer best alternatives to culture and isolation method of diagnosis since the tests are easy to perform, less risky and provide result within a short period. On the other hand, brucellosis can be diagnosed definitively by isolation and identification of the causative organism. This was first reported by Bruce and coworkers in 1887 when they isolated *B. melitensis* from military personnel in Malta [63].

The diagnosis of brucellosis by culture and isolation of organisms from clinical samples is the gold standard method. But this method is laborious, time consuming and risky, whereas the outcome of the test depends on the competence of the laboratory personnel. In clinical brucellosis, valid samples to diagnosis the disease include aborted fetuses (stomach, spleen and lung), fetal membranes, vaginal secretions, colostrum, milk, sperm and fluid collected from arthritis or hygroma [58]. At slaughter, in order to confirm suspected cases of acute or chronic brucellosis, the preferred tissues are the genital and oropharyngeal lymph nodes, the spleen and the mammary gland and associated lymph nodes [64]. The presence of antiBrucella antibodies suggests exposure to Brucella spp. But it does not indicate which Brucella spp induced production of those antibodies [65].

Bacteriological Diagnosis: This refers to isolation and identification of Brucella from clinical samples. The morphology of the Brucella bacterial colonies is associated with the presence of lipopolysaccharides (LPS) in the external membrane of the bacterium. Smooth (S-LPS) and rough (R-LPS) phenotypes are differentiated. The S-LPS phenotype is found in most Brucella species and only B. canis and B. ovis possess the R-LPS [66]. Brucellosis is usually diagnosed in the laboratory by the culture of blood, milk or tissue or the detection of antibodies in sera. Brucella organisms can be recovered from the placenta, but, more conveniently, in pure culture

from the stomach and lungs of aborted fetuses. For isolation of brucella, the recommended medium is Farrell's medium, which contains six antibiotics. But other selective Brucella media are also in use for the growth of this pathogen from fresh Camel milk and other tissue samples [67].

Serological Diagnosis: Rose Bengal plate test (RBPT): Among many types of serological test employed for diagnosis of brucellosis in camel and other domestic animals, RBPT is a widely used screening test for regulatory control and export requirements. Rose Bengal Plate Test (RBPT) is one of a group of tests known as the buffered Brucella antigen tests which rely on the principle that the ability of IgM antibodies to bind to antigen is markedly reduced at a low pH [68]. RBPT is a very sensitive test and is suitable for screening herds for brucellosis, but it can give false positive results due to vaccination with *B.abortus* strain 19 vaccine or cross reactions with other bacteria [69]. The RBPT has been reported to have high sensitivity; therefore false negative responses are reported to occur less frequently than false positive responses [70]. RBPT detected antibody in the sera of 50% of the animals suspected for brucellosis [71].

Complement Fixation Test (CFT): The Complement Fixation Test (CFT) allows the detection of anti-Brucella antibodies that are able to activate complement. Many authors regarded the CFT as being the most sensitive and specific test for brucellosis diagnosis. Because CFT antibodies remain in the serum for longer period of time than SAT antibodies [72].

Enzyme Linked Immuno Sorbent Assay (ELISA): ELISA was first developed for the diagnosis of human brucellosis. The ELISA tests offer an excellent sensitivity and specificity whilst being robust, fairly simple to perform with a minimum of equipment and readily available from a number of commercial sources in kit form. A comparison with the SAT, ELISA yields higher sensitivity and specificity. ELISA is also reported to be the most sensitive test for the diagnosis of neurobrucellosis [73] .

Molecular Methods: Polymerase Chain reaction (PCR): The isolation of Brucella organisms is still the preferred method of diagnosis. But, PCR method allows typing of the isolated strains. PCR based assays have been developed for brucellosis diagnosis and are based on the detection of specific gene sequences of the pathogens. One of the first PCR assays to differentiate among Brucella spp was called AMOS- PCR, developed by Bricker and Halling in 1994. This PCR uses a single reverse primer, targeting the Brucella specific insertion element IS711 [74]. Even though PCRs can discriminate between Brucella species and between wild and vaccine strains, but it does not discriminate between Brucella biovars. In recent time new PCR techniques are being implemented for both identification and phenotypic biotyping [75].

Public Health Importance of Camel Brucellosis

Significance and Source of Infection: Brucellosis is a systemic infection that can involve any organ or organ system of the body. Since many cases of brucellosis go unrecognized, the true incidence of the disease is unknown. In human, the disease is common in rural and pastoral areas, because farmers or pastoralists live in close contact with their animals and often consume fresh unpasteurized dairy products. In addition, pastoralist handles aborted cases with bare hand which is the main predisposing factor of the disease in the area [76]. Food producing animals such as cattle, sheep, goats, pigs and camel are also the main sources of brucellosis to human being [77]. The type of Brucella to which an individual exposed is a significant determinant factor of the risk of disease and its severity in humans. This will be influenced by the species of host animal acting as source of infection [78].

Interpersonal and occupational transmission: Person to person transmission of brucellosis can rarely occur among innocent camel herders through close personal or sexual contact while occupational exposure usually was resulting from direct contact with infected animals and food borne transmission [79]. Blood donation/tissue transplantation and bone marrow transfer are the prominent interpersonal transmission ways of brucellosis. Even though, *B. abortus*, *B. suis* and *B. canis* are considered as potential causative agents of brucellosis in human, *B. melitensis* is the most virulent brucella with a few organisms (10 to 100) being sufficient to cause a debilitating chronic infection [80].

Manifestation of Brucellosis in Human: Brucellosis may present with acute or insidious onset, with continued, intermittent or irregular fever of variable duration, profuse sweating, fatigue, anorexia, weight loss, headache, arthralgia and generalized aching. Abscess formation is a rare complication [81]. Brucella endocarditis and neuro brucellosis cause most deaths [82]. Sometimes, the

manifestations of brucellosis are more pronounced in a specific organ system. The most common local manifestations are: spondylitis, peripheral arthritis (especially of the hip, knee and shoulder) and epididymo-orchitis [83]. Arthritis and joint pain are common and usually migratory in character, affecting mostly the large joints, with unilateral joint involvement being more common among the younger age group [84]. In human's brucellosis essentially acquired by the oral, respiratory, or conjunctival routes, but ingestion of raw contaminated milk constitutes the main risk to the general public where the disease is endemic. Though camel milk ingestion is a known mechanism for brucellosis acquisition, only a few reports of sporadic cases have been published in the medical literature [85].

Public Health Importance of Camel Brucellosis in Ethiopia: As it was stated above, pastoral community of Ethiopia mainly depends on camel and other domestic animals milk and milk product to fulfill their dietary requirement which is the well-known transmission route of brucellosis from camel to human [86]. On the other hand, traditional types of food animal slaughtering in non-hygienic methods are common practices which definitely downgrade the hygiene, safeness and wholesomeness of food of animal origin. Consumption of such contaminated food which may contain Brucella bacteria has the potential to cause an adverse health effect [87]. Somali regional state and Afar pastoralists do not use any protective materials during handling parturient camels, removing placenta and/or other aborted materials since most of the people had poor knowledge about brucellosis. So, these practices could potentially facilitate the transmission of zoonotic Brucella pathogens from camel to human. They also believed that, camel milk to possess superior shelf life, medicinal properties (against dropsy, jaundice, diabetes and glycaemia) [14]. Generally, human brucellosis is increasing in Ethiopia like many other developing countries due to various sanitary, socioeconomic and political factors [88]. Thus, collaborative work of different stakeholders to prevent and control the disease as well as to enhance public awareness level of camel keepers is required [89].

Treatment of Brucellosis in Animals: As a general rule, treatment of infected livestock is not attempted because of the high treatment failure rate, cost and potential problems related to maintaining infected animals in the face of ongoing eradication programs [90]. In developed countries, treatment of infected animal is not a common practice. However, the infected animals are isolated, culled or slaughtered to prevent the spreading of infection to another herd. Even though the complex nature of brucellosis makes it difficult to treat, long term treatment with an antibiotic is thought to be beneficial to care for economically valuable breeding male animal and must be instituted before irreparable damage to the epididymis has occurred [91].

Treatment of Brucellosis in Human: Humans are treated with antibiotics (doxicycline with rifamipicine) even though relapses are possible [54]. Several conventional antibiotics including tetracyclines, trimethoprim, sulfamethoxazole, amino-glycosides, rifampicin, quinolones, chloramphenicol, doxycycline and streptomycin are commonly used in clinics [92]. The World Health Organization recommends that acute brucellosis cases should be treated with oral doxycycline and rifampicin (600 mg for six weeks) [93]. However, rifampicin monotherapy is in common practice for treating brucellosis in pregnant women and combined therapy of sulphamethoxazole and trimethoprim is recommended for children [57].

Prevention and Control of Camel Brucellosis: The control of animal brucellosis has been approached with a combination of procedures: vaccination, test-and-slaughter and hygienic measures [52]. Control of camel brucellosis should be tailored to suit conditions in the particular countries where camels are raised [61]. Camel gets infection from carrier animal's sheep, goat and cattle at pasture and water area. It is the same as those for the control of the disease in populations which are already infected: economic benefits and the protection of public health [57]. Brucellosis can be controlled by test and slaughter policy and Vaccination in other livestock. However, since camel is present in developing countries of pastoral areas test and slaughtering is not applicable. There is general agreement that the most successful method for prevention and control of brucellosis in animals is through vaccination.

Control of camel brucellosis should be tailored to suit conditions in the particular countries where camels are raised. Most of these countries are poor and camels are raised by nomadic tribes. So control of camel brucellosis can be achieved through extending veterinary services to pastoral areas [94]. Factors such as the methods of animal husbandry (e.g., commingling of herds or flocks), patterns of commerce, type of facilities and degree of dedication of the owners of animals, will also determine success. However, owners have poor understanding about the transmission route of brucellosis in camels so

that, separation of parturient animals, can be difficult or even impossible to implement [66] which is a conspicuous existing gap. It was suggested that, the preferred control strategy of camel brucellosis in high camel keeping country should be based on whole herd vaccination using S19 or Rev 1 vaccinal strains preceded by blood testing using the SAT or card test on the field. Seropositive animals should be identified by branding or special ear-mark and subjected to retesting. This marking will restrict the sale of seropositive animals. Camel calves should be vaccinated at 4-8 months of age, using a full adult dose of vaccine [95].

CONCLUSION AND RECOMMENDATION

Camels play a paramount role to feed large population of the pastoral community especially in Middle East, sub-Saharan Africa including Ethiopia. On the contrary, this animal can act as a reservoir for different infectious agent and contributes a crucial role for the persistence of zoonotic disease in the Environment. Since pastoral community mainly uses Camel milk to feed themselves, they are the number one victim to zoonotic diseases such as brucellosis and tuberculosis. Brucellosis is a zoonotic bacterial disease which results in significant economic lose and affect public health at large. In camel brucellosis can be transmitted by direct contact with infected animals and liking of the aborted fetus or new born calf which results in delayed first calving age and reduced milk yield including still birth and abortion. In human; brucellosis can be acquired through drinking contaminated raw milk from infected camel and consumption of under cooked meat, direct contact with infected animals and probably through aerosol transmission. This is due to the fact that, more than 75% of the animal owners in pastoral area have no information about zoonotic camel brucellosis. In Ethiopia, research conducted on the camel brucellosis is scarce and is limited only to serological study with no confirmed isolation of Brucella bacteria. Age; sex; management and husbandry practice are considered as major risk factors whereas information related to vaccinating camel against brucellosis is not available. So, to combat the public health and economic significance of camel brucellosis there should be:

- A detailed and comprehensive study plan to access the major risk factors aggravating the widespread occurrence and zoonotic transmission of the disease shall be designed.
- Working to enhance the awareness level of the society about zoonotic disease. For instance, informing not to touch aborted fetal material without using protective wearing's in addition to abstaining them themselves from drinking raw milk.
- Collaborative work among human and animal health professionals.

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