Clinical Manifestations of Brucellosis in Domestic Animals and Humans

Jane Megid[*,1], Luis Antonio Mathias[2] and Carlos A. Robles[3]

[1]*UNESP - Universidade Estadual Paulista - School of Veterinary Medicine and Animal Science- Department of Veterinary Hygiene and Public Health, Botucatu-SP, Brazil*

[2]*UNESP - Universidade Estadual Paulista - School of Veterinary Medicine and, Agrarian Science- Department of Veterinary Hygiene and Animal Reproduction-SP, Brazil*

[3]*National Institute for Agricultural Technology (INTA) CC: 277 (8400) Bariloche, Argentina*

Abstract: Brucellosis in domestic animals is a chronic disease that is characterized mainly by reproductive signs in cattle, buffaloes, pigs, sheep, goats and dogs. In females the disease is characterized by abortion, placenta retention, vaginal secretions, low fertility rate and also embryonic and neonatal death. In males, regular findings include epididymitis, orchitis, uni- or bilateral testicular atrophy, sperm abnormalities and infertility. Lymphadenopathy, hepatopathy, splenomegaly, uveitis and discospondylitis may also be observed in dogs. In horses, the typical clinical sign is characterized by a granulomatous supraspinous or supra-atlantal bursa lesion. Infected animals can also be asymptomatic. Infected symptomatic or asymptomatic animals represent an important source of infection to other animals and humans. Brucellosis in humans can cause undulant fever, malaise, insomnia, anorexia, headache, arthralgia, constipation, sexual impotence, nervousness and depression. For all species the presentation of clinical signs are only suggestive of disease infection and thus must be differentiated from other diseases.

Keywords: Brucellosis, clinical signs, review, cattle, buffaloes, dogs, sheep, goats, human.

INTRODUCTION

Brucellosis is one of the most important infectious causes of reproductive disorders in domestic animals. The disease is also called contagious abortion, infectious abortion, and epizootic abortion. In horses it received the name of "fistulous withers" and "poll evil". In cattle, this illness is called Bang in tribute to the Danish veterinarian, who was the pioneer in the study of this disease in this species. This illness in humans received the name of Malta fever, Mediterranean fever and Gibraltar fever according to the region in which the illness was first described. It is also known as undulating fever due to its oscillating temperature presented by infected persons.

Clinical signs vary according to the animal species that is being infected and the infecting *Brucella* species.

BRUCELLOSIS IN CATTLE

Bovine brucellosis is usually caused by *B*. *abortus* which has seven different biovars, named 1, 2, 3, 4, 5, 6 and 9. Biovar 1 is the most important and widespread *B. abortus* biovar. Among 530 *B. abortus* samples isolated from humans and animals in Latin America from 1968 to 1991, 399 (75.3%) were biovar 1 and most of them were isolated from cattle [1]. Natural infection with other *Brucella* species is rare. In areas where *B. melitensis* infection is enzootic in small ruminants, it is rarely seen abortion in cattle even though some infected animals may become carriers and excrete the bacteria in the milk [2]. In France, Verger *et al*. [3] reported that 15% of the strains isolated from cattle had all the features of *B. melitensis*. Dafni *et al*. [4] described foci of *B. melitensis* infection in cattle in Israel, but the occurrence of abortion was not confirmed. *B. suis* infection in cattle is self-limiting and thus it is not sustained [5].

Sexually mature females are more susceptible to *B. abortus* infection than bulls [2]. This susceptibility increases during pregnancy, and animals get more susceptible with the advance of pregnancy [6]. *B. abortus* infection in calf is self-limiting [7].

The period of incubation varies considerably and it is mainly influenced by gestation, exposure dose, age, and vaccination [2]. The length of the incubation period is inversely proportional to the stage of gestation at the time of exposure. Bang [8] observed an abortion in a three-month pregnant heifer 56 days after feeding her with the cotyledons from an aborting cow. Other experimental studies have shown incubation periods varying from 53 to 251 days [9].

The major clinical sign in pregnant females is abortion in bovine and buffalo cows (Fig. **1**). Abortion usually occurs from the 5th to the 8th month of gestation. The occurrence of abortion is related to some factors, such as the stage of pregnancy, the number of infecting organisms and the animal resistance [2]. Fitch *et al*. [10] examined 41 gravid uteri and *B. abortus* was not isolated from uteri before 4.5 months of pregnancy; the organism, however, was isolated from 13 out of 29 uteri that were in gestation later than 4.5 months. Bang [8] observed that infected pregnant females usually abort only once, and concluded that infected cows acquire immunity. Alternatively to abortion, premature,

*Address correspondence to this author at the UNESP - Universidade Estadual, Paulista- Faculdade de Medicina Veterinária e Zootecnia - Departamento de Higiene Veterinária e Saúde Pública - 18618-000- Botucatu-SP, Brazil; Tel 00551438116270; Fax: 00551438116075;
E-mail: jane@fmvz.unesp.br

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stillborn or weak calves may occur. Abortion is often followed by placental retention and metritis, which may cause permanent or transient infertility [11].

Fig. (1). Bubalin aborted fetus due to *Brucella abortus* biovar 1 infection.

Brucellosis does not usually result gross organic lesions [12, 13], but sometimes a mild interstitial inflammatory reaction in the mammary gland may be observed [14], which is associated with elimination of bacteria in the milk. Mammary gland macrophages may provide the intracellular environment for the persistence of *B. abortus* in the mammary gland of chronically infected cows [15].

Despite being susceptible to the infection [16], no clinical signs have been observed in infected heifers at prepubescent stage. Edgington and Donham [17] reported that 15 heifers experimentally infected with *B. abortus* before breeding failed to abort during the subsequent pregnancy, but there are evidences that heifers infected before adulthood may abort and contribute to maintain the infection in the herd [18].

The pathogenic action of *B. abortus* infection in bulls has long been established. Schroeder and Cotton [18] isolated the causal agent during the autopsy of a bull from an epididymis abscess, and Buck *et al*. [19] isolated it from bulls with seminal vesiculitis and/or orchitis. Infection of the reproductive tract may leads to orchitis, epididymitis, ampullitis and seminal vesiculitis. Orchitis is occasionally manifested, and when it occurs it is usually unilateral, but both testicles may be affected. Scattered foci of necrosis coalesce to produce total testicular necrosis (Fig. **2**) [20]. Atrophy of testicle may also occur [21, 22]. Plant *et al*. [22] considered that the syndrome involving seminal vesicles and ampoule is apparently more common than the one involving the testicles and epididymides.

The incubation period of brucellosis in bulls has not been clearly determined. Lambert *et al*. [23] observed orchitis due to strain 19 of *B. abortus* ten days after vaccination, and Danks [24] reported orchitis due to the same strain seven months after vaccination. Lubbehusen and Fitch [25] reported no clinical changes in three young bulls challenged with *B. abortus* on three occasions over a six-month period. Plant *et al*. [22] observed, in one bull, that the time from infection to the development of orchitis was at least 122 days. Occasionally, hygromas [26] and arthritis [27] are observed.

Brucellosis may result in fetal pneumonia, and to the naked eye the only recognizable lesion is a consolidation of the lungs associated with a grayish mottling in a certain number of fetuses [28]. Nevertheless not all the brucellosis aborted fetuses have pneumonia, and lung lesions are not specific enough to enable us to incriminate *B. abortus* as the cause of abortion [29]. Others gross lesions are also frequently described in aborted fetuses. Xavier *et al*. [14] observed that cows that were experimentally infected with *B. abortus* presented either weak newborn calves or aborted fetuses with mild peritonitis and abdominal organs covered with a small amount of fibrinous exudate, and such exudate was also found in their pericardium.

Fig. (2). Necrosis in the testicle (right) of a *Brucella abortus* infected bull with unilateral orchitis.

BRUCELLOSIS IN PIGS

B. suis is the only species that causes systemic infection leading to reproductive problems in the swine. Swine can be infected by other *Brucella* species but the infection is invariably self-limiting [30].

Clinical signs of *B. suis* infection in the swine vary considerably, depending on the animal age, previous exposure, and the organ involved [31]. Manifestations of swine brucellosis are abortion, birth of weak piglets, infertility, orchitis, epididymitis, spondylitis of especially the lumbar and sacral regions, arthritis, paralysis of hindlimbs, and lameness, but many infected herds may have no signs. There is no pyrexia, and death is rare [30]. Abscesses of different sizes frequently occur in organs and tissues [11].

The rate of abortion is higher in sows or gilts exposed to *B. suis via* the genital tract at the time of breeding. Abortions may occur at any time and are influenced more by the time of exposure to the *B. suis* rather than by the stage of gestation [30]. Abortions have been observed as early as 17 days following natural insemination by boars disseminating *B. suis* in the semen. Early abortions are usually unnoticed by the owner, and the only evidence of infection is that the sow displays signs of estrus 30 to 45 days after mating. Little or no vaginal discharge is observed in early abortions. Abortions that occur during mid or late stages of gestation are usually associated with females that acquire infection after 35 to 40 days of pregnancy [31]. Affected sows rarely

have a second abortion, and females infected before sexual maturity hardly ever abort [11]. A clinically apparent abnormal vaginal exudate is seldom observed in sows that have uterine infection [30].

Some infected boars do not develop a localized genital infection. However, boars that do develop genital infection seldom recover from it. Infertility and lack of sexual activity may occur in infected boars and is frequently associated with testicular involvement (Fig. **3**). More commonly, boars have infections in their accessory genital glands; however this does not necessarily reduce fertility [30]. Infection of the genital organs lasts for a shorter period of time in the female than in the male [11].

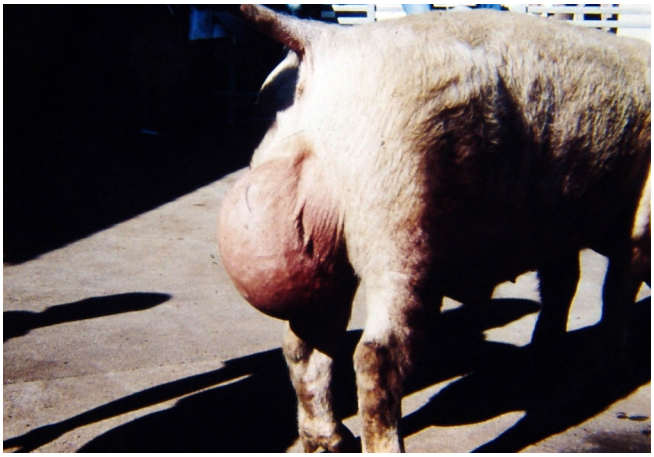

Fig. (3). Boar. Unilateral testicular enlargement due to *Brucella suis* infection. (Photograph from Correa, WM).

The disease is more common in adults. Clinical evidence of brucellosis in suckling and weaning piglets is usually absent. Clinical manifestations of arthritis and lameness or spondylitis associated with paralysis of hindlimbs are occasionally observed in any age of swines [30].

BRUCELLOSIS IN SHEEP AND GOATS

Brucellosis in sheep and goats are mainly caused by *B. melitensis* and *B. ovis*. However, other types of *Brucella* can infect sheep and goats. *B. abortus* was isolated from eight sheep and from their offspring over a period of 40 months [32] and *B. suis* was isolated from the semen of a ram [33].

Brucella infection produces a chronic disease on sexually mature animals, being the genital tract the main target of the bacteria. *B. melitensis* affects both species, being abortion in females the main clinical sign, whereas *B. ovis* affects only sheep and it is the cause of contagious epididymitis of rams [34, 35]. The effect of the disease at flock level is characterized by a general decrease in flock fertility, an increase in lamb/kid mortality with a low weaning percentage, a decrease on milk production and an increased culling of males due to chronic lesion on reproductive organs [36-39].

BRUCELLOSIS IN SHEEP AND GOATS DUE TO *BRUCELLA MELITENSIS*

The goat is considered the primary host for *B. melitensis*, which seems to be the case in Latin America and Malta, where sheep are not significantly infected, meanwhile in the Mediterranean countries, sheep and goats are equally infected [35, 37, 38].

Since *B. melitensis* is the least species-specific *Brucellae*, it can be isolated from a wide range of domestic and wild animals and is the cause of Malta fever, one of the most important zoonotic diseases. Man is infected following both contact with infected animals or the consumption of infected raw milk, and non pasteurized dairy products like the soft goat or sheep cheeses [11, 35, 39, 40, 41].

The disease is widespread all over the world, being endemic in some European countries particularly in the Mediterranean region, Latin America except for Brazil and Chile, Center and West Asia, Middle East and sporadically other nations from Africa, and India. However, North America, South East Asia, Australia and New Zealand are believed to be free [37, 42].

B. melitensis preferentially locates in the reproductive tract and lymphatic ganglia of females and males. However, it can colonize the central nervous system, bone marrow, mammary glands, bones, renal cortex and synovial membranes, producing focal granulomatous lesions [43, 44].

The infection of sheep and goats occur mainly through the nasopharynx route. *B. melitensis* can also be transmitted from the mother to the lamb/kid "in uterus" or *via* the colostrum or milk [45]. *Via* lymphatic vessels the bacteria reach the regional lymph nodes and if local defenses fail in controlling the infection, following a bacteremic phase, the uterus will become infected. In a more advanced phase *B. melitensis* can colonize the udder of lactating goat and sheep females, resulting in acute mastitis with the production of clotted and watery milk and reducing milk yields [34, 43].

The main clinical signs of *B. melitensis* infection in the female are abortion in the last 2 months of gestation, placenta retention, and giving birth to weak offspring, who usually die in the peripartum. The placenta of an aborted female can show grey necrotic cotyledons and edema [46, 47]. Animals generally abort only once. It has been reported that abortion in female goats is produced between 3 and 4 weeks after being experimentally infected with high doses of *B melitensis*. However, in sheep the abortion may occur between 4 to 12 weeks after being experimentally infected, and it seems that ewes are more resistant to abortion [37].

Infected females that have aborted will shed large numbers of *Brucella* to the environment, contaminating pastures, soil, and water. Shedding of *Brucella* through the vaginal fluid can be extended to 2 or 3 months after the abortion or parturition in goats, whereas in sheep it extends to about 3-4 weeks. In future parturition, the infected females, despite having a normal delivery, will continue shedding bacteria through the placenta, vaginal fluids and milk [35, 37].

Aborted fetuses can be in different development stages and have a normal aspect. In many cases it can be found bronchopneumonia, hemorrhagic fluid in the thoracic cavity, and enlarged lymph nodes, liver and spleen [37].

In sheep and goat males, the infection can be located in testis, epididymis, seminal vesicle and ampulla of deferent ducts, producing inflammation of genital organs. In the acute phase, it can be detected orchitis with inflammation of tunica

vaginalis, and the scrotal sac can be distended by an either hemorrhagic or fibrino-purulent exudate. In a chronic stage, hygromas and joints' inflammation can be observed in male goats. The main output of the disease in males is semen of bad quality and a consequent fertility loss [38, 43, 44].

BRUCELLOSIS IN SHEEP DUE TO *BRUCELLA OVIS*

Brucella ovis is responsible for a disease in rams known as Contagious Epididymitis. When ewes become infected, abortion can occur as well as an increase in neonatal lamb mortality, but this is less frequent than in *B. melitensis* infection [48, 49]. Ovine brucellosis due to *B. ovis* occurs worldwide affecting most of the countries where sheep is raised [50-59].

Although the initial clinical signs on rams are often unnoticed, pyrexia, lassitude and increased respiratory rate may occur associated with swollen testis and epididymis, pain and accumulation of exudate in the scrotal sac. Palpable epididymitis can appear between 15 to 45 days after experimental conjunctival inoculation [60-61].

In the chronic stage of the disease the epididymis can be increased in size up to four or fivefold (Fig. **4**). At palpation the affected epididymis is firm, even hard with an irregular contour. There may be adhesions between the epididymis, the parietal tunica vaginalis and the testes [49, 60, 62]. It is necessary to have in mind that some infected rams showing palpable lesions at one examination may be clinically normal a few weeks later [63] and that not all the *B. ovis* infected rams are going to develop lesions in their external genital organs [64, 65]. In a study carried out on Corriedale rams it could be observed that only 22 (28%) out of 78 infected rams showed evident lesions in epididymis [66].

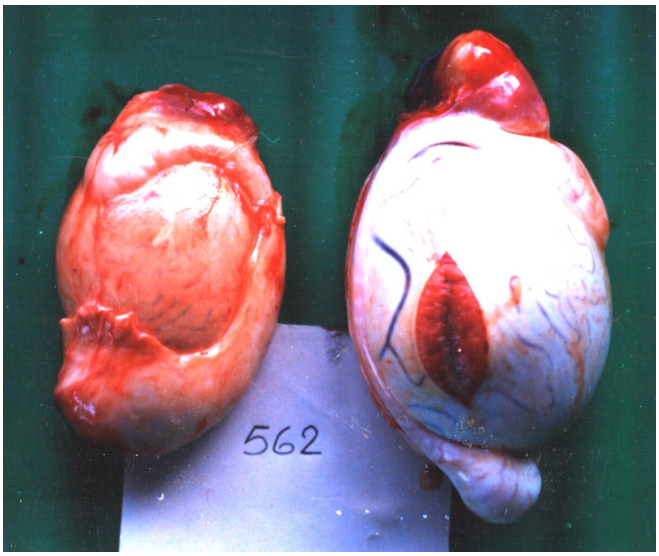

Fig. (4). Epididymitis in rams due to *Brucella ovis* infection. Notice the increase in size of the right epididymis.

Even though the epididymis may be totally affected, the tail of the epididymis is the most common output record at clinical examination. Robles *et al.* [67], examining 75 infected rams with lesions, reported that 70% had the tail of the epididymis affected, 14% the head, body and tail, 7% the body and tail, 4% body, 4% the head and body and 1% only the head. Affected rams have normal libido. However, semen quality is variable. Spermatozoa concentration and motility are often reduced, with morphological defects on the tails and detached heads [68]. Neutrophils are also commonly present [58, 59].

Clinically, the disease can be presumptively diagnosed in the ram by the palpation of external genital organs. Both testicles and epididymides are palpated simultaneously, comparing their size, shape, consistency, and symmetry [40, 69, 70]. Clinical signs and lesions described cannot be regarded as decisive since there are organisms other than *B. ovis*, including *Actinobacillus seminis*, *Histophilus ovis*, *Corynebacterium* spp., *Escherichia coli*, *Pasteurella* spp., etc., that also produce palpable epididymitis and orchitis [71-73]. Therefore, other techniques, such as bacteriology and serology, need to be used to accurately diagnose the disease.

BRUCELLOSIS IN HORSES

The infection is caused by *B. abortus* and occasionally *B. suis*. The disease is acquired through contact with infected cattle or swine, ingestion of contaminated food or water and *via* penetration of the skin or mucous membrane. Brucellosis in horses can either remain asymptomatic [74] or it can be associated with clinical disease.

Experimental infection with *B. abortus* in horses induced only mild pyrexia. However, granulomatous lesions were observed in lung, liver, testes and metatarsophalangeal synovial membranes. The mares bred normally without abortion or other signs [75, 76]. The disease is mainly recognized as an inflammation of the supraspinous and supra-atlantal bursa. These syndromes are known as "fistulous withers" and "poll evil" respectively. The bursal sac becomes distended by a clear, viscous, straw-colored exudate and develops a thickened wall. It can rupture, leading to a secondary point of infection (Fig. **5**).

Fig. (5). "Fistulous withers" due to *B. abortus* infection. Left scapular region.

Not all cases of poll evil and fistulous withers are associated with *Brucella*; other bacteria such as *Streptococcus zooepidemicus* may be involved. *Brucella*-associated abortions are rare in horses. Other clinical signs reported in horses due *B. abortus* infection are arthritis, intermittent lameness, lethargy and swelling of carpal joint [77-79].

BRUCELLOSIS IN DOGS

Brucella canis infection is one of the main infectious causes of reproductive disorders in wild and domestic dogs. The greatest prevalence rates probably occur among breeding dogs in commercial kennels [80] where significant reproductive losses can be seen. Up to 75% fewer puppies may be weaned from affected kennels according the hygienic and sanitary conditions [80, 81].

Clinical signs vary from asymptomatic to mild, despite an ongoing systemic infection. Morbidity is high but mortality is low. Bacteremia develops within two to three weeks after infection; the incubation period to clinical reproductive signs is variable [82].

The classic sign of canine brucellosis is late abortion, which can occur between 30-57 days of gestation, being more common from 45 to 55 days of gestation in about 75% of the cases. Abortions are followed by mucoid, serosanguineous, brownish or gray vaginal discharge that persists for up to six weeks [82, 83]. Brucellosis does not change the presentation of estrus and breeding [83]. The infected female can produce consecutive abortions and present litters of sick-born pups that die a few hours to more than one month after delivery. Birth of apparently normal offspring who develop the disease later can occur [82-87]. Abortions, premature litters and conception failures are observed in infected kennels [81, 88].

Resorption or early embryonic death within 2 to 3 weeks after breeding can also occur [82, 83]. The female is considered infertile since no outward signs of fetal death were seen. Pups are lost as early as 20 days or are carried nearly to term. Infected bitches may deliver a normal litter the next pregnancy or give birth to living, partly autolyzed, stillborn and normal pups that die within hours. The surviving pups are bacteremic for a minimum of several months [83], other congenitally infected pups can be born normal and later develop brucellosis. Some pups have transient fever, leukocytosis or seizures as manifestations of systemic infection. The bitch can abort two to three litters consecutively, continue to be bred and have a normal litter later [83]. Clinical signs can occur during subsequent pregnancies in some dogs but not in all of them [82].

B. canis targets androgen-dependent organs in the infected dog. The main clinical manifestations in males are severe epididymitis, orchitis and prostatitis. Epididymitis usually begins 5 weeks after infection. Acute onset of inflammation with pain and swelling enables the physical examination detection of orchitis and epididymitis. During the acute phase, the epididymis increases in size, accompanied by pain and presence of serosanguineous fluid in the tunica. Scrotal dermatitis develops from a constant licking by the male leading to edema and dermatitis which usually presents secondary contamination by non-hemolytic staphylococci [83, 87].

History of failure to achieve intromission from pain, unwillingness to ejaculate or successful internal ties without pregnancy is reported by the owners [66, 83]. Teratospermia with spermatozoa showing acrosome deformities, protoplasmatic droplets and midpiece defects are found. Other sperm abnormalities, such as dag-like defect, head defects and head-to-head binding sperm, are observed at 16 and 18-27 weeks after infection. Inflammatory cells composed of macrophages with phagocytized sperm cells surrounded by masses of neutrophils are observed later. In the chronic phase, sperm absence or reduced number of immature sperms, as well as a decrease in size and hardness of testicles can be observed. Not only that, but unilateral or bilateral atrophy and even complete sterility are found and they are associated with the autoimmune antisperm antibodies. It can also be seen reluctance to breed and/or loss of libido due to the painful experience [82, 83, 87]. *B. canis* persists in prostate gland and epididymis of infected males for several months, being disseminated by seminal fluid and urine [82].

In pre-pubescent males and females, bacteremia is frequent and the main clinical manifestation is generalized lymphadenopathy. The retropharyngeal lymph nodes may enlarge after oral infection and the superficial inguinal and external iliac nodes may do the same after vaginal infection [80, 87]. Besides lymph nodes, the spleen and liver may become enlarged. The granulomatous reaction makes the spleen firm and nodular [80].

Non-specific reported signs are: poor hair coat, listlessness, fatigue, lethargy, exercise intolerance, weight loss, lameness, back pain, generalized lymph nodes enlargement, loss of libido, premature aging and behavioral changes [82, 83]. Clinical signs are not pathognomonic for canine brucellosis but it should be a primary consideration in dogs with reproductive failure or infertility [83-87].

Other clinical signs like discospondylitis, meningitis, focal non-suppurative encephalitis, osteomyelitis, uveitis (Fig. **6**) and abscesses in various internal organs [80, 89-91] are observed in infected dogs influenced by the bacteremia [80]. Discospondylitis is accompanied by acute pain in the vertebral column, lameness, paresis, ataxia and compression of the medulla [83, 87, 92]. Chronic or recurrent uveitis in the absence of systemic disease in infected dogs were reported by Ledbetter *et al*. [93]; the clinical ophthalmological abnormalities were unilateral and included mild-to-moderate anterior uveitis, iris hyper pigmentation, marked vitreal infiltrates, and multifocal chorioretinitis.

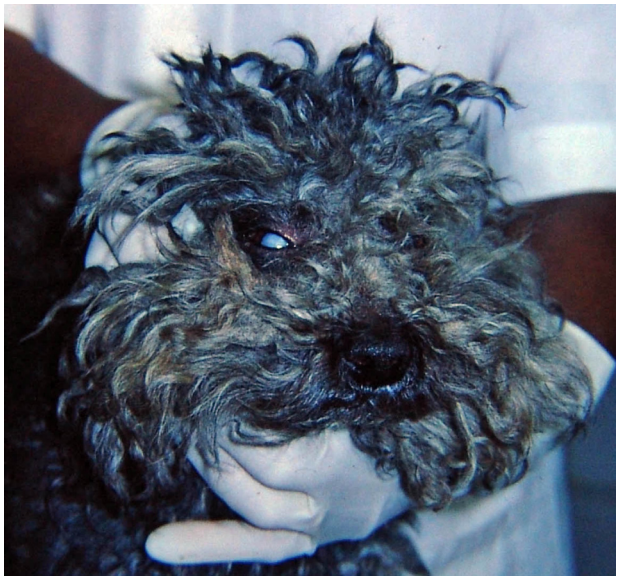

Fig. (6). Uveitis in a dog due to *Brucella canis* infection.

Clinical signs are not pathognomonic, and can result from causes other than *B. canis* infection. Wanke *et al*. [94] observed abortion, infertility, perinatal mortality, discospondylitis, orchitis, epididymitis, uveitis, prostatitis in similar distribution among serologically negative and positive dogs, demonstrating the need of laboratorial diagnosis confirmation.

Clinical signs of *B. abortus* in dogs vary from mild fever to orchitis and testicular atrophy with shedding of organisms in urine [95-97]. Dogs experimentally infected with *B. suis* were reported afebrile and asymptomatic without gross lesions [98], but in natural conditions hindlimb weakness, large and firm epididymitis was observed associated to oligospermia and increased number of neutrophils in semen [99] similar to what was observed in *B. canis* infection.

Dogs with brucellosis may recover spontaneously as soon as one year after infection, but recovery is more common after 2 to 3 years after it, and some dogs remain chronically infected for at least five years [80].

BRUCELLOSIS IN HUMANS

B. abortus, *B. melitensis*, *B. suis*, *B. canis*, and marine mammal *Brucella* species are human pathogens. In humans, brucellosis can be a serious, debilitating and sometimes chronic disease that may affect a variety of organs. Most cases are caused by occupational exposure to infected animals or the ingestion of unpasteurized dairy products [80]. The incubation period is 1-3 weeks but can be extended to several months. *B. melitensis* is the most important cause of human brucellosis worldwide [1,100], and it is associated with acute infection (< 2 months) whereas the infection with other *Brucella* species are usually subacute (2-12 months) or chronic (> 1 year) [100]. In countries where *B. melitensis* was not demonstrated, *B. suis* was more frequently isolated [1]. The most common signs of brucellosis are undulant fever in which the temperature can vary from 37ºC in the morning to 40ºC in the afternoon; night sweats with peculiar odor, chills and weakness. Malaise, insomnia, anorexia, headache, arthralgia, constipation, sexual impotence, nervousness and depression are also common. Fever was observed in 77.8% of infected patients, followed by joint pain (21%), low backache (14%) and several other symptoms in lower proportion [100].

Complications and involvement of internal organs can be diverse, depending on the site of infection, and include encephalitis, meningitis, spondylitis, arthritis, endocarditis, orchitis, and prostatitis [11]. Although unusual, spontaneous abortions have been seen in pregnant women infected with *Brucella* in early stages. *Brucella* endocarditis is a rare severe complication most commonly associated with *B. melitensis* and is responsible for at least 80% of deaths due to brucellosis [100, 101]. Splenomegaly (17.2%), hepatomegaly (10.1%) and hepatosplenomegaly (15.1%) were observed associated to clinical signs [100].

Neurological complications can occur during the onset of illness, convalescence period or even some months after recovery from an acute infection. Meningitis, encephalitis, meningoencephalitis, brain abscess, chorea, facial palsy, meningomyeloencephalo-spondylosis and ischemic attach have been reported [102, 103]. *Brucella* meningitis in infants was correlated to human breast milk transmission [103] and neurobrucellosis and intracerebral granulomas were reported in two patients infected with marine strains of *Brucella* [104]. Unusual manifestations of brucellosis as liver abscesses, pancytopenia, and acute pancreatitis were reported as caused by *B. melitensis* infection [105, 106].

B. canis infections have been reported in humans presenting recurrent fever, granulomatous hepatitis, splenomegaly [107], prolonged febrile illness [108], weakness, liver and spleen enlargement, submaxillary adenopathy [108], and attention must be taken to serological diagnostic results once there is no cross reaction between *B. canis* and smooth strains normally used in diagnostic tests for human diagnosis.

CONCLUDING REMARKS

Brucellosis in animals and humans is worldwide distributed and being considered one of the most important zoonosis. It is a chronic disease and can develop several clinical forms, presenting from reproductive to systemic clinical signs and sometimes being asymptomatic. Affected symptomatic or asymptomatic animals represent important source of infection eliminating the agent through secretions and excretions. Humans are affected by contact with infected animals or through the ingestion of contaminated food. Marine species of *Brucella* have been recognized lately and there are reports of human infections with these species, demonstrating the wide range and adaptability of these bacteria.

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