JSM Veterinary Medicine and Research

Review Article

A Review on Bacterial and Fungal Diseases in Dogs

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Abstract

The objective of this article was to briefly review about the most common bacterial and fungal infections in pet animals especially dogs by describing information about the causative agent, clinical signs and symptoms, route of transmission and diagnosis of the infection. In last years, the pet population has increased and the interest in having pets where are became sharing in our daily life in many purposes such as protection, entertainment, hunting and helping their owner, etc... . Thus, the increase of the knowledge and awareness of dog owners regarding these diseases enable them to significantly reduce the occurrence of these infections. Bacterial infections such as *Pasteurella, Salmonella, Brucella, Yersinia enterocolitica, Leptospira, Campylobacter, Bordetella bronchiseptica,* and *Coxiella burnetii*, and fungal infections including *Aspergillosis, Candidiasis* and *Dermatophytosis* are the most common bacterial and fungal infections affecting dogs.

Keywords: Bacterial infections; Fungal infections; Dogs

Introduction

Sometimes, dogs have positive impacts on psychosocial and psychical status of their owners compared to others may be suffering from depression and mental stress **[1]**. Dogs are susceptible to several types of infectious diseases can be worrisome for their owners because some of them are fatal if not treated soon enough. Bacterial and fungal infections can be contracted through different parts of body. Furthermore, many of them are zoonotic infection among humans and dogs. The signs of any disease typically depend on location of infection either local infection or systemic infection. The local infection usually involves the skin surface that look like wounds and swellings may be appear firm or soft and may be contain discharges. These discharges depend on consistency and color may be varying from watery to thick with different color. While systemic infection depends on affected organ that notice signs such as coughing, sneezing, diarrhea, loss appetite and loss of weight. The majority of households keep dogs for many purposes in their life. Thus, this review focused on an overview of the most common bacterial and fungal infections found in dogs and clinical signs, and how they are diagnosed.

I-Bacterial Diseases

Pasteurellosis

Pasteurella is a normally inhabited bacterium in upper respiratory tract of dogs under normal circumstances. It is a zoonotic disease can be transmitted into human, and have the most prevalent among animal populations. Pasteurellosis is systemic bacterial disease and clinically characterized by respiratory distress and pneumonia.

Etiology and clinical findings

Pasteurella spp. is a small, Gram negative, non motile, facultative, anaerobic coccobacillus. It cause the endemic disease in dogs and can be transmitted to human by direct and indirect contact like dog biting, licking, contact with nasal discharge and scratches [2]. *Pasteurella spp* commonly affect the soft tissues and wounds infections after infection transmission. Therefore, the manifestation and clinical signs relevant to Pasteurella infection ranged from mild symptomatic to sever, acute to chronic infection, often fetal and/or disseminated infections [3]. Mild symptoms include sneezing, copious mucous secretions, mild rhinitis, mild pneumonia with labored breathing, and fever and can be progress to disseminated diseases [4]. Many studies reported that *Pasteurella* causes septic arthritis, meningitis, endocarditis, peritonitis, pneumonia, sepsis and deep-seated abscesses [5-7].

Diagnosis

Conventional methods are the most frequently used for detection and diagnosis of Pasteurellosis. An observation of the stained bacterium under microscope and isolation on selective media and followed by serological analysis. The specimens may be required for examination such as blood sample, nasal swabs. Microscopic examination of fresh culture or specimens using Giemsa stain or Leishman's stain shows bipolar-staining rods. Pasteurella isolate and grow well at 37°C on selective media such as 5% sheep's blood in dextrose-starch, casein-sucrose-yeast (CSY), Mueller-Hinton and brain heart infusion (BHI) agar. These media were prepared by adding antibiotics like vancomycin, clindamycin, gentamicin, neomycin, kanamycin, amikacin either singly or in combination to select for *Pasteurella* [8]. Furthermore, biochemically are positive for catalase, oxidase, indole, and ornithine decarboxylase [9].

Salmonellosis

Salmonella is a zoonotic infection and can be transmitted by many species of animals and human. A member of family

Submitted: 17 April 2019 | **Accepted:** 21 June 2019 | **Published:** 26 June 2019

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Citation: Abd Alfatah ME (2019) A Review on Bacterial and Fungal Diseases in Dogs. JSM Vet Med Res 2: 7.

Enterobacteriaceae is widely distributed and transmitted either direct or indirect contact (fecal-oral transmission) [10]. The main clinical signs of *Salmonella* are gastrointestinal disorders, manifested by gastroenteritis, fever and bacteremia.

Etiology and clinical signs

Salmonella spp is Gram negative, anaerobic, non-motile, bacilli that multiply and colonize in large intestine especially in distal part of colon and mesenteric lymph nodes. There are predisposing factors increase the risk of *Salmonella* including dog's age either young or older dog due to their under developed or/and compromised immune system and administration of antibiotic therapy for long time that make imbalance between the beneficial bacteria in GIT and harmful one.

The prevalence of *Salmonella* in dogs is a highly variable depending on the environment which the dogs live. For instance, *Salmonella* isolates from stray dogs were higher than those from the household dogs [11]. However, the majority of infected animals is asymptomatic and can shed the microorganism in feces for 6 weeks [12]. Therefore, the clinical signs of Salmonella may be asymptomatic carrier or exhibit variation in clinical signs depending on the severity of infection. These signs include fever, diarrhea often bloody, lethargy, depression, loss of appetite and dehydration but in severe cases may be fatal.

Diagnosis

The conventional methods are frequently used for detection and diagnosis. Sample may be required for Salmonella diagnosis is the fecal sample. The fecal sample is prepared and cultivated on specific media like Xylose lysine deoxycholate (XLD) agar, Hekeon enteric agar and Brilliance Salmonella agar then incubate for 24h at 37°C to determine the presence of *Salmonella*.

Serological assays are rapid tests and the most commonly used for *Salmonella* diagnosis such as *Salmonella* agglutination and Rapid latex agglutination test [13].

Brucellosis

Brucellosis is a contagious zoonotic disease. *Brucella canis* is transmitted among dogs by venereal and oral transmission and reported in human cases had contact with body fluid of infected dogs. The incubation period of *Brucella* may last from one week up to several months [14]. The main clinical signs in dogs is reproductive problems characterized by abortion in late stage of pregnancy in female and orchitis, epididymitis and prostatitis in male [15].

Etiology and clinical signs

Brucella canis is Gram negative, coccobacilli, faculatative intracellular bacteria belong to genus *Brucella*. Other *Brucella species* such as *B. abortus, B. melitensis* and *B. suis* occasionally associated with disease in dogs [16].

Brucellosis has no specific clinical signs but when appear symptoms, it usually related to reproductive problems. *Brucella canis* can cause abortion mostly during the last trimester (45 - 55 days) followed by a mucoid, serosanguinous or gray-green vaginal discharge persist for several weeks or cause early embryonic deaths or stillbirth frequently die after birth. While in male dogs may cause epididymitis and scrotal edema and orchitis in acute stage of infection. Concurrent prostatitis is common that result to pain and difficulty in urination and defecation. Lymphadenitis is common and may be regional or generalized in infected dogs. In case of chronic infection may be occur unilateral or bilateral testicular atrophy. Some males become infertile due to morphological abnormalities in sperm and reduced viability. Occasionally, discospondylitis, chronic uveitis, unilateral endophthalmitis, dermatitis, endocarditis, osteomyelitis and meningoencephalitis have been reported [17, 18].

Diagnosis

Definitive diagnosis of *Brucella canis* is based on isolation and identification from the clinical specimens. The specimens may be required for detection is placenta, vaginal secretion and ejaculate. These samples are prepared and cultivated on selective media such as Farrell's, Thayer-Martin's or CITA medium. Therefore, microscopic examination of stained smears from specimens using modified ZiehlNeelsen staining that show as coccobacilli, often singly but sometimes in pairs or small groups.

Serological assays are more available and often used to diagnose the infection of *B. canis.* The commonly serological tests used for diagnosis are the rapid slide agglutination test and the tube agglutination test. As soon as 2-4 weeks after infection some dogs seroconvert, but others may not have detectable titers until 3-4 months. Therefore, positive results in screening tests should be confirmed by more specific tests such as ELISAs [19]. Even PCR tests for *Brucella* are mainly used to identify organisms in culture and often used directly in clinical samples [20].

Yersiniosis

Yersiniosis is a zoonotic bacterial disease can be transmitted among animal species and human by direct contact with infected animals or ingestion of contaminated food and water (fecal-oral transmission) [21]. This is one of the enteric bacterial diseases that clinically characterized by acute diarrhea.

Etiology and clinical signs

Yersinia enterocolitica is Gram-negative, faculatative anaerobic, coccobacillus bacterium belonging to the family of *Enterobacteriaceae*. *Yersinia enterocolitica* subdivided into 5 strains (1A/1B, 2, 3, 4, 5) and 76 serotypes. Some strains of this species can produce a thermostable enterotoxin [22]. The disease is manifested and clinically characterized by fever, watery or bloody diarrhea, abdominal cramps, anorexia and vomiting. These symptoms may last from 1-3 day up to 3 weeks then occur self-limiting or may complicated and take place osteomyelitis, hepato-splenic abscesses, skin ulcers, conjunctivitis, meningitis, pharyngitis, urinary infections or septicaemia [23-25]. Others appear without observable symptoms [26].

Diagnosis

To confirm the diagnosis and differentiate the *Yersinia enterocolitica* from other enteropathogenic bacteria which

have gastroenteritis symptoms. Fecal samples were taken and prepared for isolation and identification of the causative agent. Samples were cultivated in yersinia selective agar and incubated for 24 h at 30°C to isolate *Yersinia*. *Yersinia* biochemically characterized by esculin hydrolysis, indole production, and the ability to ferment D-xylose and D-trehalose [27]. Serology is used to detection the infection with *Y. enterocolitica* is available using *Y. enterocolitica* O:3, O:5, O:8, O:9, and O:27 commercial antisera.

Leptospirosis

Leptospirosis is a widely distributed zoonotic bacterial disease can be transmitted through direct contact with contaminated soil, water and urine. Rodents act as a major reservoir for *Leptospira* [28]. The incubation period of this disease may be ranged from 2 to 26 days [29] and the highest incidence is associated with period of rainfall. *Leptospira* can affect on many organs such as liver, kidney and blood vessels and manifested by fever, vomiting and diarrhea [30, 31].

Etiology and clinical signs

Leptospira is Gram negative aerobic bacterium related to order *Spirochaetales*, family *Leptospiracae*. It is fastidious bacteria, slow growing and have characteristic corkscrew like motility. The genus leptospira is divided into two species *L. interrogans* and *L. biflexa* and subdivided into multiple serovars. Serovars were reported in dogs including *icterohaemorrhagiae, grippotyphosa, bratislava, canicola* and *pomona* [32].

Leptospirosis may present variety of symptoms and the common clinical signs appear on dogs including anorexia, lethargy, vomiting, diarrhea, abdominal or lumbar pain, musculoskeletal pain and dehydration [33, 34]. Uveitis, renal and hepatic diseases have been also observed as well as ventricular tachyarrhythmia may be accompanied with myocardial damage in some dogs [35]. However, other cases may appear without any symptoms.

Diagnosis

Diagnosis of leptospirosis depends on clinical examination and vaccination history and laboratory diagnosis. Serological tests are the most frequently used in diagnosis of leptospira in dogs that used to detect antibodies against the organism and also detect the organism in body fluid. Widespread leptospiral vaccines in dogs complicate interpretation of leptospiral serology. Generally, vaccinated dogs develop relatively low agglutinating antibody titers (1:100 to 1:400) in response to vaccination, and these titers persist for 1–3 months after vaccination. However, some dogs develop high titers after vaccination which persists for 6 months. Other diagnostic tests are used such as PCR and culture but the sample should be collected before antibiotic administration for maximal sensitivity. Samples may be required for culture are blood, urine, or tissue samples. These samples were prepared and cultivated specialized culture medium to identify the infecting serovar. Blood may be cultured early stage of infection; but urine may be positive through 7–10 days after clinical signs appear.

Campylobacteriosis

Campylobacterosis is an infectious bacterial disease that found in intestinal tract of dogs. Campylobacter is usually transmitted by ingestion of contaminated food and water or direct contact with contaminated objects. The clinical signs are characterized by mild to moderate diarrhea.

Etiology and clinical signs

Cambylobacter spp is Gram negative bacteria, spiral in shape that exhibits a characteristic corkscrew darting motility and moved by a single polar flagellum. The *Cambylobacter jejuni* and *C. coli* are the highest prevalence and usually result in campylobacter enteritis in dogs. Dogs and puppies represent the major reservoirs for campylobacter [36]. The incubation period of campylobacter varies from one to seven days. Most infected dogs appear without observable symptoms but, others show symptoms. The observable clinical signs are often watery and may be associated with bloody diarrhea, fever, vomiting and abdominal pain. Some nervous signs including convulsion and seizure may be observed in some cases [37].

Diagnosis

Diagnosis of Campylobacteriosis depends on isolation of the causative agent using selective media. The sample may be required for diagnosis is fresh fecal sample that should be used for processing within 2 days. Microscopic examination for pure colonies showed gram-negative and curved rods. Biochemical tests are used for identify different species including its ability to hydrolyze hippurate, and negative catalase production. Furthermore, other diagnostic tests as PCR are used for identification of infection if the culture is difficult [38].

Bordetellosis (kennel cough)

Bordetella bronchiseptica is an infectious bacterium that normally lives in upper respiratory tract. *B. bronchiseptica* may be transmitted among dogs living in close places which are considered one of the most prevalent respiratory infections of dogs. it is clinically characterized by frequent dry and hacking coughing with high morbidity and low mortality rate [39].

Etiology and clinical signs

Bordetella bronchiseptica is Gram negative, aerobic, coccobacillus bacterium. It belongs to genus *Bordetella*, and family *Alcaligenaceae.* This genus is consisted from nine species including *B. bronchiseptica, B. pertussis, B. parapertussis, B. parapertussis, B. hinzii, B. avium, B. holmseii, B. trematum and B. petrii* [40, 41]. *B. bronchiseptica* has been associated with zoonotic respiratory infections [42].

There are predisposing factor enhance the virulence and chance of colonizing this pathogen in respiratory tract associated with the impairment of immune system, direct cellular injury of respiratory epithelium [43]. Incubation period ranged from 1 to 8 days and the clinical signs extend for 1–2 weeks. Infected dogs may shed the pathogen for 2–3 months after recovery. Bordetellosis have two clinical forms, the first form is a typical

and the most common which is associated with dry hacking cough, gagging and retching behavior in dogs while, the second form is a complicated and more common in puppies or immuno–compromised dogs which characterized by wet cough. This disease is accompanied with mucoid discharges and signs of systemic infection including pyrexia, anorexia, chorioretinitis, vomiting and diarrhea in severe cases, finally resulting in death of the puppies [44].

Diagnosis

Diagnosis of bordetellosis depends on the isolation of the *B. bronchiseptica* followed by the identification of the organism by biochemical tests, serological and molecular methods. Samples can be taken from nasal swab and throat swab and then prepared for isolation of *Bordetella species* which grow readily on blood agar, Bordet-Gengou agar, Smith-Baskerville culture media and MacConkey agar at 37°C. Biochemically, *Bordetella* are positive for oxidase, catalase and citrate utilization and are negative for fermentation of any sugar, production of gelatinase, DNase, indole and H2S [45].

Serological tests are often considered the best method to facilitate the diagnosis of *Bordetella* in case of difficulty in isolation. Commonly serological tests used for diagnosis include tube agglutination, indirect haemagglutination, micro-agglutination test and ELISA [46,47].

PCR has been exploited to achieve the fast and accurate detection of *Bordetella* in clinical samples because the isolation and identification is a time consuming process and serological tests have not good specificity [48].

Coxiellosis

Coxillosis is a zoonotic bacterial infection that causes Q-fever in human. *Coxiella burnetii* infects a wide range of animals including ruminants, dogs, cats, arthropods mainly ticks, birds and human. The most common reservoir of *C. burnetii* are cattle, sheep and goat as well as, some studies approved that possible act infected dogs and cats as reservoirs for Q-fever [49, 50]. The route of transmission of *C. burnetii* occur through two major patterns either the organism circulates between animals via tick bites or by inhalation of contaminated aerosols, ingestion of contaminated raw milk or food, or direct contact with body fluid or placenta [51,52]. This disease is clinically characterized by reproductive disorders.

Etiology and clinical signs

Coxiella burnetii is Gram negative, coccobacillus, obligatory intracellular bacterium. Previously, it classified as a rickettsial agent, but recently phylogenetic analyses found that *C.burnetii* is more closely related to *Legionella* and *Francisella* than to the genus *Rickettsia*. It reproduces in phagolysosomes of host monocytes and macrophages. It has two forms exist: the first is the large cell variant which is a vegetative form found in infected cells, while the second is the small cell variant which is the extracellular infectious form shed in milk, urine, and feces and found in high concentration in placental tissue and amniotic fluid. The small cell variant is resistant to heat, drying, and many common disinfectants and remains viable for weeks to years in the environment [53]. Incubation period may persist from 8 to12 days after exposure to infection. Infection in animals is usually subclinical and infected cases are asymptomatic. However, some infected animal showed reproductive disorders including abortions, stillbirths, retained placenta, infertility, metritis and weak newborns [54, 55].

Diagnosis

Diagnosis of *C. burnetii* depends on tissue culture of suspected infected dogs or aborted fetus. Due to difficulty in cultivation, serological test such as indirect immunofluorescence assay and ELISA are available for diagnosis of *C. burnetii*. Serologic testing is in combination with PCR recommended due to PCR of whole blood or serum can be positive in very early stages after symptom onset but becomes negative as the antibody titer increases and after administration of antibiotics [56,57].

II- fungal diseases

Aspergillosis

Aspergillosis is an infection caused by the Aspergillus fungus, which is found worldwide. This infection has two types, nasal form and disseminated form. Both types can occur in cats and dogs, but they occur more frequently in dogs. It is primarily respiratory infection which may become generalized.

Etiology and clinical signs

Aspergillus species is fungus that widely distributed in environment and has capacity of growing in different substrates. There are different species cause disease in dogs including *Aspergillus fumigatus, Aspergillus flavus, Aspergillus terreus, Aspergillus niger* and *Aspergillus deflectus*. Several studies reported that aspergillosis affects every age, but it primarily affects young to middle-aged animals [58]. Aspergillosis in dogs has two forms, nasal aspergillosis is caused predominantly by *Aspergillus fumigates* which accompanied with unilateral or bilateral profuse purulent to mucopurulent nasal discharge, lethargy, nasal pain, sneezing, ulceration surrounding the nostrils and open-mouth breathing. Ocular discharge and exophthalmos may be seen[59].

Dissimenated aspergillosis is generalized form of infection that usually caused by *Aspergillus tereus, Aspergillus deflectus,* and *Aspergillus niger*. Infection mostly occurs through entrance fungus into the respiratory tract and goes to the lungs, then hematogenous spread into other sites including the intervertebral discs of the spine or the kidneys and irises as well as other organs, muscles, and bones. This disease usually take several months to appear the signs of infection including vertebral pain progressing to partial or complete paralysis or lameness of a limb with pronounced swelling, anorexia, weight loss, lethargy, fever, weakness, vomiting, blood in the urine and lymph node enlargement [60].

Diagnosis

Definitive diagnosis of aspergillosis depends on isolation and identification of the fungus through culture. Samples may be

acquired from urine, nasal swabs, lymph node aspiration, CSF. Sample was inoculated on specific media such as Sabouraud's dextrose agar (SDA). The isolates were identified on the basis of morphology and cultural characters [61]. Microscopic examination for urine and different specimen may be showed many branching hyphae.

Candidiasis

Candida spp are ubiquitous and saprophytic yeast which widely distributed in a variety of animals. Candidiasis is localized fungal disease affecting skin and mucous membranes and genital and gastrointestinal tracts of dogs. There are predisposing factors such as injury to any of the mucous membranes, the use of catheters, administration of antibiotics, and immunosuppressive states help in developing candidosis.

Etiology and clinical signs

Candida spp are normally inhabited in skin, digestive tract, upper respiratory and genital mucosa of animals. *C. albicans* and *C. parapsilosis* are the most common isolations [62]. Under normal conditions, these organisms may transform into pathogens causing different infections and clinical signs may be localized or generalized. Signs of infection are variable and non specific such as skin lesions, oral lesions and diarrhea, all may be associated with predisposing conditions than with the candidiasis itself. Systemic infection appears with general symptoms according to affected organs. Peritonitis and chronic cystitis have been reported [63].

Diagnosis

Fungal diagnosis based on morphological and biochemical characters. Samples may be required from skin lesion and scraping that were inoculated into Sabouraud's dextrose agar at 25 °C. All isolates were examined by direct microscope for specimens showing ovoid, budding yeast cells with thin walls, or they occur in chains that produce pseudohyphae when the blastospores remain attached after budding division. Filamentous, regular, true hyphae also may be visible [64]. In addition, the germ tube test with human serum gave a positive result after 3 hours incubation at 37°C. Biochemically, *Candida albicans* is characterized by carbohydrate assimilation.

Dermatophytosis

Dermatophytosis is the most common fungal infection affecting skin, hair and nails in dogs and cats. It is characterized by a superficial skin infection confined to keratinized epithelium. The warm and humid climate is most suitable condition for infection. This infection is transmitted by direct contact with the infected animals or with contaminated equipment with fungus such as grooming equipment. Incubation period of infection may be developed within 1 to 3 weeks [65].

Etiology and clinical signs

Dermatophytosis is caused mainly by *Microsporum canis*, but *M. gypseum* and *Trichophyton mentagrophytes* have been reported in some cases. Many infected dogs appear without any signs but may be subclinical infected. When the infection developed the signs appear as a regular and circular alopecia, with erythematous margin and a thin desquamation. Lesions can be single or multiple, and are localized on any part of dog and Multiple lesions may coalesce [66].

Diagnosis

Diagnosis is made by identification of the infection in dogs by culture and microscopic examination. Wood's lamp examination seek for fluorescence on the infected hair shafts with *M. canis* but the negative result does not rule out the infection [67]. Direct microscopic examination of hairs and scales specimens of infected dogs shows the presence of fungal hyphae and/or ectothrix spores. This examination is considered very important in the diagnosis of dermatophytoses.

Definitive diagnosis for Dermatophytosis is done by fungal culture. Samples may be required from scraping or biopsy specimens were inoculated into fungal culture media include Sabouraud's dextrose agar and dermatophyte test medium [68].

Conclusion

There are several bacterial and fungal infections are zoonotic and infectious can infect both human and animals and can be transmitted by pet animals. Among them, dogs are responsible for transmission of these infections to their owners. Thus, dog owners should be had some information regarding to their route of transmission to reduce these infections and recommended the preventive methods to avoid these infections and application food hygiene protocol such as good cooking meat. Furthermore, the dogs should be fed on good cooked meats to prevent campylobacter and salmonella infection. In addition, cleaning the grooming equipment is very important to prevent the fungal infection and so on. Moreover, the knowledge about clinical signs and symptoms of each disease and diagnostic methods are important for treatment, prevention and control, besides public health problem, because these animals are more inserted in our daily life, maintaining close contact with us.

References

1. Beth TR, M Nokota. *Pet companionship and depression: results from a United States Internet sample.* Anthrozoos: A Multidisciplinary Journal of The Interactions of People & Animals. 2006. **19**: 50-64.
2. Oehler RL. *Bite-related and septic syndromes caused by cats and dogs.* Lancet Infect Dis. 2009. **9**: 439-447.
3. Wilson BA, M Ho. *Pasteurella multocida: from zoonosis to cellular microbiology.* Clin Microbiol Rev. 2013; **26**: 631-655.
4. Klein NC, BA Cunha. *Pasteurella multocida pneumonia.* Semin. Respir. Infect., 1997; **12**: 54-56.
5. Grangeon V. *[Pasteurella multocida lung abscess. Study of a case with demonstration of a cat as vector].* Rev Mal Respir. 2000; **17**: 693-696.
6. Boerlin P. *Molecular identification and epidemiological tracing of Pasteurella multocida meningitis in a baby.* J Clin Microbiol. 2000; **38**: 1235-1237.
7. Voss A. *Sepsis puerperalis caused by a genotypically proven cat-derived Pasteurella multocida strain.* Eur J Obstet Gynecol Reprod Biol. 1998; **76**: 71-73.

8. Avril JL, PY Donnio, P Pouedras. *Selective medium for Pasteurella multocida and its use to detect oropharyngeal carriage in pig breeders.* J Clin Microbiol. 1990; **28**: 1438-1440.

9. Lariviere S. *Comparison of isolation methods for the recovery of Bordetella bronchiseptica and Pasteurella multocida from the nasal cavities of piglets.* J Clin Microbiol. 1993; **31**: 364-367.

10. Morse EV, *Canine salmonellosis: A review and report of dog to child transmission of Salmonella enteritidis.* Am J Public Health. 1976. **66**: 82-84.

11. Tsai HJ. *Salmonellae and campylobacters in household and stray dogs in northern Taiwan.* Vet Res Commun. 2007; **31**: 931-939.

12. Leonard F. *Salmonella infection and carriage: the importance of dogs and their owners.* Vet Rec. 2014; **174**: 92-93.

13. Lowden P. *Investigating the prevalence of Salmonella in dogs within the Midlands region of the United Kingdom.* BMC Vet Res. 2015; **11**: 239.

14. Lucero NE. *Human Brucella canis outbreak linked to infection in dogs.* Epidemiol Infect. 2010; **138**: 280-285.

15. Boeri E. *[Canine brucellosis in dogs in the city of Buenos Aires].* Medicina (B Aires). 2008; **68**: 291-297.

16. Greene CE. *Canine Brucellosis: Infectious diseases of the dog and cat. 3th ed. St. Louis: Saunders Elsevier.* 2006.

17. Cosford KL. *Brucella canis: An update on research and clinical management.* Can Vet J. 2018; **59**: 74-81.

18. Aiello SE. MA Moses. *The Merck veterinary manual*, in *Brucellosis in dogs.*, N. Kenilworth, Editor. 2016; Merck and Co.

19. Barkha S. S Dharmendra Kumar, S Dhirendra Kumar. *Immunochemical characterization of antigens of Brucella canis and their use in seroprevalence study of canine brucellosis.* Asian Pac J Trop Med. 2011; **4**: 857-861.

20. Akhtardanesh B. *Serological evidences of canine brucellosis as a new emerging disease in Iran.* Asian Pacific Journal of Tropical Disease. 2011: 177-180.

21. European Food Safety Authority. *The community summary report on trends and sources of zoonoses, zoonotic agents and food-borne outbreaks in the European Union in 2008.* EFSA J. 2010; **8**: 1496.

22. Fredriksson-Ahomaa M. H Korkeala. *Low occurrence of pathogenic Yersinia enterocolitica in clinical, food, and environmental samples: a methodological problem.* Clin Microbiol Rev. 2003; **16**: 220-229.

23. Byun JW. *Hepatic yersiniosis caused by Yersinia enterocolitica 4:O3 in an adult dog.* J Vet Diagn Invest. 2011; **23**: 376-378.

24. Wibbelt G. DF Kelly. *Sudden death in a Rottweiler puppy with myocardial yersiniosis.* Eur. J. Vet. Pathol. 2001; **7**:135-137.

25. Farstad L, T Landsverk, J Lassen. *Isolation of Yersinia enterocolitica from a dog with chronic enteritis: a case report.* Acta Vet Scand. 1976; **17**: 261-263.

26. Neubauer H. *[Yersinia enterocolitica infections: 1. Impact on animal health].* Berl Munch Tierarztl Wochenschr. 2001; **114**: 8-12.

27. Bockemuhl J. JD Wong, *Yersinia*, in *Manual of clinical microbiology*, P.R. Murray, et al., Editors. 2003, ASM Press: Washington, DC.

28. Moore GE, *Canine leptospirosis, United States, 2002-2004.* Emerg Infect Dis, 2006; **12**: 501-503.

29. Sehgal S. *Epidemiological patterns of leptospirosis.* Indian Journal of Medical Microbiology, 2006; **24**: 310.

30. Arent ZJ. *Emergence of novel Leptospira serovars: a need for adjusting vaccination policies for dogs?* Epidemiol Infect. 2013; **141**: 1148-1153.

31. Miller MD. *Variability in results of the microscopic agglutination test in dogs with clinical leptospirosis and dogs vaccinated against leptospirosis.* J Vet Intern Med, 2011. **25:** 426-432.

32. Zuerner RL, *Genus Leptospira*, in *Bergey's Manual of Systematic Bacteriology.*, N.R. Krieg, et al., Editors. 2010, Springer-Verlag.: New York, NY, USA.

33. Goldstein RE. *Influence of infecting serogroup on clinical features of leptospirosis in dogs.* J Vet Intern Med. 2006; 20: 489-494.

34. Greenlee JJ. *Clinical and pathologic comparison of acute leptospirosis in dogs caused by two strains of Leptospira kirschneri serovar grippotyphosa.* Am J Vet Res. 2004. **65**: 1100-1107.

35. Greene CE. *Leptospirosis*, in *Infectious Diseases of the dog and cat*, C.E. Greene, Editor. 2006. Saunders Elsev: St Louis.

36. Hermans D. *Poultry as a host for the zoonotic pathogen Campylobacter jejuni.* Vector Borne Zoonotic Dis. 2012; **12**: 89-98.

37. Gazaigne L. *Campylobacter fetus bloodstream infection: risk factors and clinical features.* Eur J Clin Microbiol Infect Dis. 2008. **27**: 185-189.

38. de Boer RF. *Improved detection of five major gastrointestinal pathogens by use of a molecular screening approach.* J Clin Microbiol. 2010; **48**: 4140-4146.

39. Bhardwaj M. BR Singh, P Vadhana. *Bordetella bronchiseptica infection and kennel cough in dogs.* Adv. Anim. Vet. Sci. 2013; **1:** 1-4.

40. Gerlach G. *Evolutionary trends in the genus Bordetella.* Microbes Infect, 2001; **3**: 61-72.

41. Mattoo S. JD Cherry, *Molecular pathogenesis, epidemiology, and clinical manifestations of respiratory infections due to Bordetella pertussis and other Bordetella subspecies.* Clin Microbiol Rev, 2005. **18**: 326-382.

42. Cotter PA. JF Miller, *Bordetella* in *Principles of bacterial pathogenesis*, E.A. Groisman, Editor. 2001, Academic Press: London. UK

43. Ford RB. *Canine infectious tracheobronchitis*, in *Infectious Diseases of the Dog and Cat*, C.E. Greene, Editor. 2012: St. Louis: Saunders.

44. Edinboro CH, MP Ward, LT Glickman. *A placebo-controlled trial of two intranasal vaccines to prevent tracheobronchitis (kennel cough) in dogs entering a humane shelter.* Prev Vet Med. 2004; **62**: 89-99.

45. Denes AL. *Biochemical tests used for identification of Bordetella bronchiseptica.* Buletinul USAMV–CN. 2006; **63**: 67-70.

46. Kumar S. *Studies on occurrence of Bordetella infection in pigs.* 2013, Indian Veterinary Research Institute: Izatnagar, India.

47. Ellis JA. *Effect of vaccination on experimental infection with Bordetella bronchiseptica in dogs.* J Am Vet Med Assoc. 2001; **218**: 367-375.

48. Bhardwaj M. *Poor association of Bordetella bronchiseptica infection with kennel cough in dogs in northern India.* Universal J. Microbiol. Res. 2013; **1**: 10-14.

49. Angelakis E, D Raoult, *Q fever.* Veterinary Microbiology. 2010; **140**: 297-309.

50. Sykes JE. *Canine and Feline Infectious Diseases.* Elsevier Health Sciences, Louis, Missouri, 2013.

51. Khalili M, E Sakhaee, *An update on a serologic survey of Q Fever in domestic animals in Iran.* Am J Trop Med Hyg. 2009; **80**: 1031-1032.

52. Andoh M. *Survey of Coxiella burnetii in ticks collected from dogs in Japan.* J Vet Med Sci. 2013; **75:** 1115-1117.

53. Greene CE. *Q fever (Chapter 46)*, in *Infectious Diseases of the Dogs and Cats*, C.E. Greene, Editor. 2012, Elsevier Saunders: St Louis.

54. Gwida M, M El-Ashker, I. Khan, *Q fever: a re-emerging disease?* Journal of Veterinary Science & Technology. 2012; **3**: 1-5.

55. Cantas H. *Q fever abortions in ruminants and associated on-farm risk factors in northern Cyprus.* BMC Vet Res. 2011; **7**: 13.

56. Klee SR. *Highly sensitive real-time PCR for specific detection and quantification of Coxiella burnetii.* BMC Microbiol. 2006; **6**: 2.

57. Healy B, H van Woerden, D Raoult, *Chronic Q fever: different serological results in three countries–results of a follow-up study 6 years after a point source outbreak.* Clin Infect Dis 2011; **52**: 1013-1019.

58. Kelly SE. SE Shaw, WT Clark. *Long-term survival of four dogs with disseminated Aspergillus terreus infection treated with itraconazole.* Aust Vet J. 1995; **72:**311-313.

59. Gilbert JJ, *Fungal Infections*, in *The Merck Veterinary Manual*, E.A. Susan and M.A. Asa, Editors. 1998, Merck and RhõnePoulenc Company: Philadelphia, Pennsylvania.

60. Dallman MJ. *Disseminated aspergillosis in a dog with diskospondylitis and neurologic deficits.* J Am Vet Med Assoc. 1992; **200**: 511-513.

61. Çam Y. *Experimental Aspergillus fumigatus Infection in Dogs and Treatment with Itraconazole.* Turk J Vet Anim Sci. 2003; **27**: 1147-1158.

62. Rinaldi MG. *Biology and pathogenicity of Candida species*, in *Candidiasis: Pathogenesis, Diagnosis and Treatment*, G.P. Bodey, Editor. 1993; RavenPress: NewYork.

63. Rogers CL. *Disseminated candidiasis secondary to fungal and bacterial peritonitis in a young dog.* J Vet Emerg Crit Care (San Antonio). 2009; **19**: 193-198.

64. Willems N. *Disseminated Candidiasis in a Young, Previously Healthy, Dog and Review of Literature.* Mycopathologia, 2017; **182**: 591-596.

65. Ganguly S. P Ahmad Para, S. Showkat. *Mycological investigation of dermatophytosis in Dog: A case study.* Journal of Entomology and Zoology studies 2017; 970-971.

66. Chermette R. L Ferreiro, J Guillot, *Dermatophytoses in animals.* Mycopathologia, 2008; **166**: 385-405.

67. Miller WH. *Muller & Kirk's Small animal dermatology*. 2013; Elsevier: St. Louis.

68. Carrasco L, J Perez, *[Histopathological diagnosis of mycoses in veterinary pathology].* Rev Iberoam Micol, 2000; **17**: S18-22.

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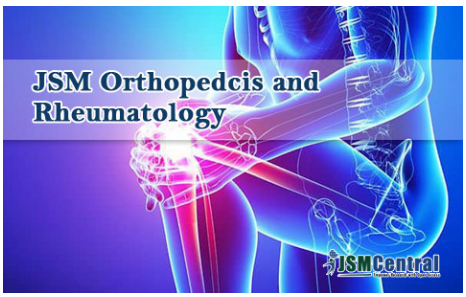

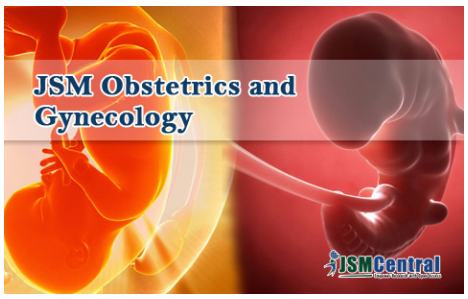

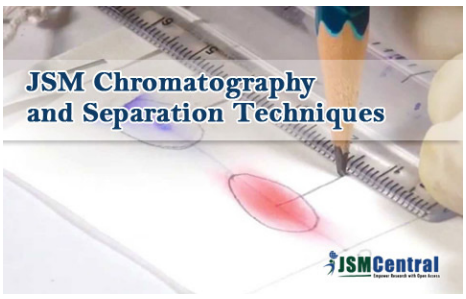

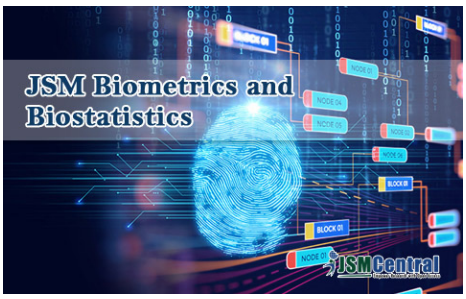

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