RAW MEAT DIET AND RISK OF ZOONOTIC BACTERIAL INFECTIONS FOR DOGS, CATS AND THEIR OWNERS

Rinosh Mani, BVSc, MS, PhD, DACVM
Section Chief, Bacteriology, VDL

Dr. med. vet. Dr. habil. Matti Kiupel, BS, MS, PhD, DACVP
Fachtierarzt für Veterinär Pathologie
Professor, Department of Pathobiology and Diagnostic Investigation

College of Veterinary Medicine
Michigan State University Veterinary Diagnostic Laboratory
4125 Beaumont Road Lansing, MI 48910
USA

Introduction

Dogs and cats are the most common pets in the United States and more than >60% of US households own pets (Bingham et al., 2010). While the dog population remained relatively stable prior to 1996, it started to increase afterwards by 3 to 4% annually (Gompper, 2013). From 2000 to 2018 the number of registered dogs in the US increased from 68 million to around 90 million (APPA, 2017-2018) and approximately 60 million US households owned a dog in 2018 (APPA, 2017-2018). Similar numbers have been reported for cats with around 47 million households owning an average of 2.2 cats amounting to around 94 million cats in US (APPA, 2017-2018). This makes the US the country with the largest number of pet dogs and cats with less than half the numbers being reported for China or Brazil as the next countries with large numbers of pet dogs and cats. Not only have the numbers of pets owned by Americans dramatically increased within the last two decades, but more than 50% of pet owners consider their dog or cat as a family member (Chomel and Sun, 2011). This has also led to changes on how dogs and cats are being handled. Close personal contact is common and around 50% of owners allow their dogs to sleep in their bed (Chomel and Sun, 2011). Similar data have been reported for cats, were 62% sleep with their adult owners and 13% with children (Chomel and Sun, 2011).

Not only do people live in much closer contact with their pets, they also try to provide their family members with as natural environment as possible. This may explain the enormous increase in people feeding their pets raw meat based on the belief that such diet would be more natural than traditional commercial pet food. While many pet owners are convinced of the benefits of such diet, scientific evidence to support such claims is lacking (Freeman et al., 2013). Raw meat diets are most often composed of raw muscle, parts of organ, bones, offal, and other tissues derived from by-products of animals slaughtered for human consumption or from animals that died prior to slaughter or were condemned at slaughter inspection, so they are usually identified as low quality

and as unfit for human consumption (FDA, 2019). While it is already problematic that such diets are not balanced for vitamins and trace elements (Dillitzer et al., 2011), these diets are usually not pasteurized and major concerns have been raised by the American Veterinary Medical Association that such diets may expose pets to various pathogenic organisms, including *Salmonella* spp., *Campylobacter jejuni*, *Listeria* spp., *Yersinia* spp. and *Escherichia coli*, and ultimately may cause disease in pets and potentially their owners (Morley et al., 2006; Nüesch-Inderbinen et al., 2019). Recent studies have also shown that the probability of transmitting multi-drug resistant bacteria found in raw foods from pets to humans is also a real possibility (Baede et al., 2017). While in the past, the primary concerns of zoonotic diseases transmitted from dogs and cats to their owners have been parasitic diseases such as migrating larvae or toxoplasmosis that were primarily transmitted through contact with pet feces or the feces contaminated hair coat of the pet or contaminated soil (Overgaauw et al., 2009), changes in both human and pet interactions and pet diet may pose a significant risk of bacterial diseases for both the animal and its owner.

This presentation will review some of the classical zoonotic bacterial diseases, such as Brucellosis and Leptospirosis, that are regaining importance in the changing environment and give an overview of recently more frequently recognized bacterial infections in our pets, such as Salmonellosis and Listeriosis, that in the past were more commonly associated with transmissions from production animals. Lastly, we will briefly discuss the risk of some normal bacterial flora of dogs and cats causing zoonotic disease.

Brucellosis

The threat of *Brucella* from pet foods was highlighted in a recent report in the Journal of Emerging Infectious Diseases. A dog in the Netherlands developed classical Brucellosis symptoms and on subsequent investigation, it was found that the dog acquired the pathogen, *Brucella suis*, from raw rabbit-based diet imported from Argentina (van Dijk et al., 2018). Although this route of infection is extremely rare, the possibility of Brucellosis being contracted by companion animals fed with unpasteurized dairy products is very real.

Leptospirosis

Leptospirosis continues to be a significant health risk, especially among urban and suburban dog populations. Although canine Leptospirosis can be controlled by strict annual vaccinations, this deadly disease still affects large numbers of dogs. The situation is exacerbated by unfounded concerns over vaccine safety and efficacy. Dogs are more susceptible to the disease than cats and the bacteria can survive in the environment mostly in water puddles or any wet areas contaminated with infected urine from a reservoir animal. Infection is acquired via damaged/inflamed skin or directly through mucous membranes from which leptospires enter the blood stream (Sykes et al., 2011). Leptospirosis is a zoonotic disease and although the annual number of cases reported in humans is low, extreme precautions must be taken especially if immunosuppressed individuals are in contact with an infected dog.

Salmonellosis

Salmonellosis is one of the most common food borne bacterial disease in humans. In studies looking at bacterial contamination of raw pet food, the presence of Salmonella ranged from 7 -20% (Davies et al, 2019). Cattle, swine and poultry naturally carry this bacterium often without showing any outward clinical signs and it is very easy to contaminate raw food during the manufacturing process. A number of instances have been reported where humans contracted Salmonellosis from contaminated pet foods (Finley R, 2006).

Antibiotic resistant bacteria

Emergence and dissemination of pan-drug resistant bacteria is a huge concern in human as well as veterinary medicine. Extended spectrum beta-lactamases (ESBL) are enzymes that confer resistance to most beta-lactam antibiotics, including penicillins and cephalosporins. ESBL production and carbapenem resistance in Enterobacteriaceae is a major health concern and physicians are finding it increasingly difficult to treat these bacterial infections. European studies have revealed a higher percentage of ESBL positive *E. coli*, *Salmonella* and other Enterobacteriaceae in raw pet foods when compared to processed products (Davies et al, 2019). A strong association between the presence of ESBL producing Enterobacteriaceae in pet foods and the shedding of these antibiotic resistant bacteria in household cats raises the concern of potential zoonotic transmission (Baede et al., 2017).

Listeriosis

Listeria monocytogenes is a Gram-positive, ubiquitous saprophytic, facultative anaerobe bacillus that can grow well at low temperatures and has been classified into 4 different phenotypes with strains in lineage 2 causing mainly animal diseases and strain in lineage 1 being associated with human disease (Orsi et al., 2011). The bacilli can be most commonly found in soil, standing water or feed material and encephalitis in ruminants is commonly associated with transmission from spoiled sileage and centripedal infection through the trigeminal nerve (Hoelzer et al., 2012). Less common presentation in ruminants include septicemia in young animals or abortions (Hoelzer et al., 2012). Shedding in feces of clinically normal ruminants has been reported (Esteban et al., 2009). In humans, listeriosis causes different forms of neonatal disease and pregnancy-associated disease as well as meningoencephalitis in geriatric or immune suppressed patients, while healthy adults most commonly develop a self-limiting gastroenteritis (Hoelzer et al., 2012). In monogastric species, such as the dog and cat, disease caused by *Listeria monocytogenes* has rarely been reported in the past, but healthy animals can shed the organism. Cats were historically thought to be resistant to infections with *Listeria monocytogenes* and an initial study failed to document fecal shedding (Iida et al., 1991). However, experimental studies showed that FIV-infected cats were much less able to eliminate the bacilli from macrophages (Dean et al., 1998) and other studies estimated a prevalence of 0.04% of fecal shedding in cats (Weber et al., 1995). However, the recent surge in raw meat diets may significantly change both the prevalence of shedding and frequency of disease

observed in cats. A recent study of raw-food pet diets found Listeria monocytogenes in 54% of tested samples (Bokken et al., 2018). Only recently, we confirmed a series of 3 cats with a clinical history of weight loss, vomiting and anorexia and severe abdominal lymphadenomegaly (Fluen et al., 2019). All three cats had a severe pyogranulomatous lymphadenitis caused by *Listeria monocytogenes* (Fluen et al., 2019). Two of these cats had been confirmed to be fed a raw meat diet. Recent data in dogs raise similar concerns. While reports of disease in dogs are equally rare to those in cats, a case of septicemia in a dog was associated with a *Listeria monocytogenes* strain within lineage 1 that is usually found associated with human disease (Pritchard et al., 2016). Other reports describe tonsillitis associated with *Listeria monocytogenes* in dogs further raising the concern of potentially easy transmission to humans through licking etc. (Laikko et al., 2004).

Pasteurellosis

Pasteurella species are Gram-negative coccobacillus that commonly colonizes the oropharynx of animals. In dogs and cats, *Pasterurella multocida* is most commonly encountered as a secondary, opportunistic pathogen in respiratory diseases, but toxigenic strain may cause primary disease especially in young or immune compromised animals. Other Pasteurella species, such as *P. stomatis*, *P. canis* or *P. dagmatis*, are usually only identified as part of the normal flora of the upper aerodigestive tract and have only rarely been associated with disease in dogs and cats. In recent years, more numerous diseases have been associated with infections with *Pasteurella spp.* in humans and *Pasteurella spp.* were the most commonly isolated bacterium from dog and cat bites or scratches (Talan et al., 1999). While *Pasterurella multocida* is the most commonly encountered isolate, *Pasteurella dagmatis* represented the second most commonly identified isolate in one study (Ashley et al., 2004), while others reported 60% of isolates from infected humans as *P. multocida*, 17% *P. stomatis*, 6% as *P. canis* and only 3% as *P. dagmatis* (Holst et al., 1992) Based on the route of exposure, local skin disease or abscesses or tenosynovitis are most frequently reported in humans followed by respiratory infections. Systemic infections are less common. However, of 38 reported cases of *P. multocida* meningitis in infants, 27 (87%) of 31 infants that had been exposed directly or indirectly to the oropharyngeal secretions of a dog or cat through licking or sniffing (Kobayaa et al., 2009). Furthermore, the number of human deaths in the US caused by Pasteurellosis rose from 5 or fewer cases annually in the years from 1994 to 1999 to an average of 10 cases in the years from 2000 to 2004 and peaked at 25 cases in the year 2005 according to CD mortality reports (Wilson and Ho, 2013). While most cases of Pasteurellosis are associated with dog and cat bites and scratches causing localized disease, *P. dagmatis* infections have been more commonly associated with systemic disease and bacteremia and there are several reports of *P. dagmatis* being contracted from dogs or cats that caused endocarditis in patients with prosthetic heart valves (Strahm et al., 2012, Xiong et al., 2015). These data indicate the importance for elderly or immune compromised pet owners to pay special attention to routine hygiene measures and to avoid close contact with the saliva of their pet.

Capnocytophagosis

Most veterinarians are probably least familiar with *Capnocytophaga canimorsus* since it is usually not associated with disease in either dogs or cats. This is a fastidious, slow-growing, Gram-negative rod shaped bacterium that has been detected in colonize the gingiva of 70% of healthy dogs (Jacob and Lorber, 2015), but is not part of the normal bacterial flora of humans. More than 125 human cases have been reported over the last 40 year ranging from septicemias to cellulitis and endocarditis (Jacob and Lorber, 2015). More than 70% of affected patients had a predisposing condition or were immune compromised and exposure to a dog was confirmed in 75% of cases (Jacob and Lorber, 2015).

Conclusion

These examples highlight the importance of recognizing the potential risk of human exposure to bacterial pathogens from pets. This risk has potentiated through changes in how owners interact and live with their dogs and cats as well as the feeding of non-pasteurized diets that may be contaminated. It is also important to understand that some groups of owners, include children, elderly people or immune compromised patients, may be at special risk. In a recent survey of 265 adult patients with pre-existing disease conditions, 52% owned an animal (74% dogs and 39% cats) and 80% of those patients engaged in behavior putting them at potential risk of zoonotic infections (Gurry et al., 2017). These behaviors included picking up animal feces (52%), cleaning animal areas (50%), allowing animals to sleep in the same bed (37%) or allowing the animal to lick their face (28%). Furthermore, 30% of these patients had been bitten or scratched by an animal (Gurry et al., 2017). It should be the role of the veterinarian to educate owners about these potential risk to help them make educated decisions and protecting their health and the health of their pets.

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