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Potential Role of Pet Animals in Household Transmission of Methicillin-Resistant *Staphylococcus aureus:* A Narrative Review

Manuel Bramble,[1] Daniel Morris,[2] Pam Tolomeo,[3] and Ebbing Lautenbach[3–6]

Abstract

In this narrative review, we found numerous reports suggesting that dogs and cats may play a role in household methicillin-resistant *Staphylococcus aureus* (MRSA) transmission and recurrent MRSA infection in human contacts. Future work should emphasize elucidating more clearly the prevalence of MRSA in household pets and characterize transmission dynamics of MRSA humans and pet animals.

Key Words: Cats—Dogs—Household—MRSA—Pet animals—Transmission.

Introduction

First identified in 1961 (Boucher and Corey 2008, Kluytmans and Struelens 2009), methicillin-resistant *Staphylococcus aureus* (MRSA) now accounts for over 60% of *S. aureus* isolates in U.S. intensive care units (Boucher and Corey 2008). Methicillin resistance in *S. aureus* is independently associated with increased length of hospital stay, hospital charges, and mortality (Cosgrove et al. 2003). In the past decade, the incidence of infections due to community-associated MRSA has increased significantly (Stein 2009), and typically occurs in individuals without exposure to a healthcare setting (Leonard and Markey 2008, Oehler et al. 2009).

As MRSA increases in prevalence, focusing on the household as a primary location for MRSA transmission is justified, as this is the location where individuals spend the greatest amount of time in an average day (Bureau of Labor and Statistics 2007). Further, the household is the site of close interactions between adults and children, and *S. aureus* may be spread among household members (Hollis et al. 1995, Wagenvoort et al. 2005, Johansson et al. 2007).

The role of pet animals in the transmission of MRSA in the community is not well defined. However, those who work on farms, own pets, and work in veterinary hospitals may be at greater risk for MRSA colonization or infection perhaps because of transmission of MRSA between humans and animals (Stein 2009). Notably, the incidence of MRSA carriage in companion animals has increased substantially in recent years (Boag et al. 2004, Loeffler and Lloyd 2010).

Over 75 million dogs and 88 million cats are owned in the United States alone, making these the overwhelmingly most common pet animals (Oehler et al. 2009). However, very little is known about the role of these pet animals in MRSA transmission within the household. Intimate contact between pets (namely, cats and dogs) and their owners creates favorable conditions for MRSA transmission. If cats and dogs are shown to play a role in household transmission of MRSA, they may represent important targets for intervention to curb further transmission of MRSA in the household and the community. The goal of this narrative review is to identify the available literature regarding MRSA transmission between humans and pet animals, with a specific focus on cats or dogs in households.

Methods

A search of PubMed was conducted in July 2009 for articles of all study designs focusing on possible household transmission of MRSA involving pets animals. The search terms used were "MRSA+pets," "MRSA+dogs," MRSA+cats," "methicillin-resistant *Staphylococcus aureus*+pets," "methicillin-resistant *Staphylococcus aureus*+dogs," "methicillin-resistant

[1]University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania.
[2]Department of Clinical Studies, University of Pennsylvania School of Veterinary Medicine, Philadelphia, Pennsylvania.
[3]Center for Clinical Epidemiology and Biostatistics, University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania.
[4]Division of Infectious Diseases, Department of Medicine, University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania.
[5]Department of Biostatistics and Epidemiology, University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania.
[6]Center for Education and Research on Therapeutics, University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania.

Staphylococcus aureus+cats," "dogs," and "cats." The search was limited to articles published in the English language. The search was further enhanced by reviewing the bibliography of included articles.

The abstract of every identified article was reviewed. Only those articles describing MRSA colonization and/or infection in the household setting, with inclusion of pet animal data, were reviewed. Because pet animals other than cats and dogs (including birds, reptiles, and small mammals) experience an extremely limited exposure to the full household environment, articles concerning MRSA transmission to or from pet animals other than dogs and cats were discarded. To focus on MRSA transmission in the household setting exclusively, articles concerning the transmission of MRSA within only a healthcare or agricultural setting were not included. Two investigators (M.B. and E.L.) independently reviewed all potentially eligible articles. If disagreements arose regarding a study's inclusion, consensus was achieved through discussion among the reviewers.

Specific data elements extracted included the year and site of study, study design, patient population, number of human and pet animal subjects, MRSA status of humans and animals in the household (colonized, infected, or negative), and whether pet and owner MRSA strains were genetically related. We further assessed any antimicrobials prescribed for the pet.

Results

All 181 articles returned from the search were reviewed for content. By reviewing the 181 abstracts, duplicates and clearly ineligible articles were discarded, leaving 41 that were possibly relevant based on our desired criteria. These 41 articles were reviewed in detail, and further discarding of ineligible material took place. After this process, the final six case reports and two case series remained. No comparative studies met our search criteria. The final eight articles spanned from 1994 to 2009, and they contained a total of 12 pets (8 dogs and 4 cats) and 20 humans (Table 1). In the Weese report (Weese et al. 2006), there were six pets included of which three met our criteria for relevance to household transmission. Similarly, the Neinhoff report (Nienhoff et al. 2009) included two pets, of which only one met our criteria for inclusion.

Several of the identified cases suggest that humans are the initial source of MRSA colonization (van Duijkeren et al. 2004, 2005, Weese et al. 2006, Nienhoff et al. 2009) in the household. Several of the human subjects were exposed to various types of healthcare settings (Cefai et al. 1994, van Duijkeren et al. 2004, Weese et al. 2006), which increase the likelihood of contact with MRSA-infected humans. Moreover, the isolates found in the pets were often the same human strain that was endemic to the region of study (van Duijkeren et al. 2004, Vitale et al. 2006). These observations indicate a recurrent pattern of transmission: pets can acquire human strains of MRSA bacteria from their owners or other humans, and they are capable of causing colonization and/or infection of human cohabitants.

Discussion

Eight of the 10 case studies suggest that dogs can be vectors for MRSA bacteria (Cefai et al. 1994, Manian 2003, van Duijkeren et al. 2004, 2005, Weese et al. 2006, Nienhoff et al.

TABLE 1. SUMMARY OF REPORTS OF METHICILLIN-RESISTANT *STAPHYLOCOCCUS AUREUS* AMONG HOUSEHOLD PET DOGS AND CATS

	Cefai et al. (1994)	*Manian (2003)*	*Van Duijkeren et al. (2004)*	*Van Duijkeren et al. (2005)*	*Weese et al. (2006)*	*Vitale et al. (2006)*	*Sing et al. (2008)*	*Neinhoff et al. (2009)*
Country	United Kingdom	United States	The Netherlands	The Netherlands	Canada	United States	United States	Germany
Study design	Case report	Case report	Case report	Case report	Case series (3 cases included)	Case report	Case report	Case series (1 case included)
No. of pets in study	1 dog	1 dog	1 dog	1 dog	3 dogs	1 cat	3 cats	1 dog
Pet infection or colonization	1 infected	1 colonized	1 colonized	1 colonized	All 3 dogs infected	1 infected	1 colonized, 2 negative	1 colonized
No. of humans in study	2	2	4	3	1 human per household	1	4	1
Human infection or colonization	2 colonized	2 infected	2 colonized, 2 negative	1 infected, 2 colonized	Each human colonized	1 colonized	1 infected, 3 colonized	1 infected
Identical strains?	Yes	Yes	Yes	Yes	N/A	N/A	Yes	Yes
MRSA type	Not described	Not described	RIVM cluster 35	RIVM cluster 28, sequence type 80	Epidemic Candaian MRSA-2	USA300	ST80	ST225
Pet decolonization?	Yes	Yes	Yes	Yes	No (for all cases)	Yes	Yes	No
Drugs used for pet	Mupirocin/ triclosan	Vancomycin Ointment (5%)	Doxycycline/ rifampin	Ciprofloxacin/ rifampin	N/A	Amoxicillin, clavulanic acid, enrofloxacin	Ciprofloxacin/ rifampin	N/A

MRSA, methicillin-resistant *Staphylococcus aureus*; N/A, not available.

2009), and two of the case studies suggest that cats can be vectors as well (Vitale et al. 2006, Sing et al. 2008). Cats have already been established as reservoirs for other pathogens (e.g., *Toxoplasma gondii*) (Elmore et al. 2010). Despite the fact that the majority of relevant MRSA-related case studies focus on dogs, further surveillance of cats' role in MRSA transmission may indeed be required. The reasons for the lack of case studies examining cats' role in MRSA transmission remain unclear. Possible explanations for this include the relative difficulty of swabbing cats for data collection or the fact that dogs tend to experience closer human contact.

Four of the eight case reports noted that infection of human subjects persisted until the pet (as well as any other colonized or infected cohabitants) was treated with antimicrobials to which the bacteria were susceptible (Manian 2003, van Duijkeren et al. 2004, 2005, Sing et al. 2008). These observations are consistent with the common view that pets can serve as reservoirs of MRSA infection (Oehler et al. 2009, Stein 2009, Gaze et al. 2008, Morgan 2008), potentially causing re-infection of their owners after the owners have been treated for the initial MRSA infection. In all four cases, the human subjects were effectively cleared of infection and/or colonization after the pet and any other cohabitants were treated with antimicrobials.

After the pet was identified as a potential source of the human subject's re-infection or re-colonization, the most common approach to decolonization for pets involved a combination of two drugs, one of which was usually rifampin. Rifampin was used effectively in conjunction with ciprofloxacin (van Duijkeren et al. 2005, Sing et al. 2008) and doxycycline (van Duijkeren et al. 2004) with subsequent negative nares cultures for the pet animal. The ciprofloxacin/rifampin combination appeared to be effective in curbing further human infection in case of a colonized cat and dog (van Duijkeren et al. 2005, Sing et al. 2008), although the cat was not resampled to confirm clearance of MRSA (Sing et al. 2008). In one case (Manian 2003), 5% vancomycin ointment was used in the nares of both infected humans and the colonized dog, but complications resulted before all subjects were free of colonization and infection. In many cases, only the nares of the pet animal were surveyed for MRSA colonization. Because canine behaviors such as licking and accepting treats have been proven to increase the likelihood of MRSA transmission (Lefebvre et al. 2009), colonization of the oral cavity may also be relevant for transmission.

This study demonstrates that there is some evidence in the medical literature to support a potential role for pet animals in the transmission of MRSA in households. Although, these data are clearly only hypothesis generating at this point, they do suggest that future work to elucidate the role of pet animals in MRSA household transmission would be very worthwhile. These studies should focus on identifying the prevalence of MRSA colonization among pet animals of humans infected or colonized with MRSA. In addition, longitudinal assessment of MRSA colonization in household members as well as their pets should be undertaken to determine the transmission dynamics in the households. Further, identifying potential high-risk behaviors for transmission (e.g., face licking) should be emphasized.

Future investigations could lead to important novel interventions, which could include enhanced surveillance for MRSA among pets as well as potential decolonization of pets with MRSA carriage. For example, if pet animal MRSA colonization is found to be significantly associated with human MRSA colonization and infection, reduction of potential high risk behaviors (e.g., face licking) could be targeted to reduce transmission. Further, interventions targeting identification of MRSA-colonized pets of humans with recurrent MRSA infections could be entertained and possible strategies to decolonize MRSA-colonized pets could then be tested.

In summary, although still limited in scope, there are increasing reports that suggest that pet animals may play a role in household MRSA transmission. Future work to more clearly elucidate the role of pet animals should be emphasized with resultant endeavors to test interventions to curb the transmission of MRSA between humans and pet animals. In addition, surveillance should be expanded to companion animals other than cats and dogs, particularly those with exposure to agricultural, veterinary, and healthcare settings.

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Address correspondence to:
Ebbing Lautenbach
Center for Clinical Epidemiology and Biostatistics
University of Pennsylvania School of Medicine
825 Blockley Hall
423 Guardian Drive
Philadelphia, PA 19104-6021

E-mail: ebbing@mail.med.upenn.edu