M Boost
M O'Donoghue 唐瑪芝
A James

Investigation of the role of dogs as reservoirs of *Staphylococcus aureus* and the transmission of strains between pet owners and their dogs

Key Messages

1. Dogs may serve as a reservoir for *Staphylococcus aureus* and could be a source of infections due to this organism in humans.
2. Health care workers (HCWs) seem to be a major source of *S aureus* for colonisation of dogs, with both methicillin-susceptible and methicillin-resistant strains.
3. De-colonisation of dogs owned by methicillin-resistant *S aureus*–colonised HCWs should be carried out at the same time as decolonisation of respective HCWs and other family contacts.

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Department of Health Technology and Informatics, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong SAR, China
M Boost
School of Nursing, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong SAR, China
M O'Donoghue
Animal Unit, The Chinese University of Hong Kong, Shatin, NT, Hong Kong SAR, China
A James

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Principal applicant and corresponding author:
Dr MV Boost
Biomedical Science Section, School of Nursing, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong SAR, China
Tel: (852) 2766 6391
Fax: (852) 2364 9663
E-mail: htmboost@polyu.edu.hk

Introduction

Staphylococcus aureus is carried by approximately 25% of humans in their nasal cavities, which is a major reservoir of this pathogen. Carriage of *S aureus* is associated with certain genetic and environmental factors.[1] Resistance to antibiotics has increased the consequences of *S aureus* infections, particularly those due to methicillin-resistant *S aureus* (MRSA), an important cause of nosocomial infections.[2] Methicillin resistance is coded for by the *mecA* gene.[2] Until recently MRSA was largely confined to hospital and health care settings.[2] However, it has now been found in the community and has caused severe infections in healthy children and adults.[2] Unlike hospital-acquired MRSA (HA-MRSA), which is multi-resistant, community-acquired (CA) MRSA is usually resistant only to beta-lactams, and sometimes, erythromycin. Whereas exposure to health care and health care workers (HCWs) has been recognised as a risk factor for HA-MRSA colonisation,[2] more work is needed to identify reservoirs of CA-MRSA.

Case reports of human infection or colonisation from companion animals indicate that animals act as reservoirs for MRSA transmission.[3,4] Limited studies suggest carriage of *S aureus* occurs in less than 10% of dogs.[3] Concern about MRSA in the community has led to recommendations for surveillance of carriage levels in healthy dogs.[2,4]

No studies of MRSA carriage in companion animals have been performed in Hong Kong. This study therefore aimed to determine the level of *S aureus* colonisation in dogs and their owners, the antibiotic resistance patterns of isolates and whether the strains in dogs were the same as in their owners. Risk factors for colonisation of the respective parties were also examined, including the extent of contact between them. As levels of MRSA carriage in the community remain low,[5] levels of colonisation of companion animals and their owners with both methicillin-sensitive *S aureus* and MRSA were determined to explore the frequency of possible transmission.

Methods

This study was conducted from January 2005 to January 2006.

Study design

A cross-sectional study of colonisation with *S aureus* of dogs kept as companion animals and their owners was performed. A convenience sample of pet owners and dogs was recruited at six veterinary practices; ill dogs were excluded. Owners were provided an information sheet about the study and asked to sign a consent form.

Laboratory investigation

Specimens were collected using a sterile swab from the nostrils of human subjects. The nares of dogs were sampled by veterinarians using a small swab due to the size and sensitivity of their nostrils. The swabs were placed in transport

medium and transferred to the laboratory within 8 hours of collection. Owners completed a simple questionnaire providing relevant information about their contact with the dog and antibiotic(s) taken by the animal within the last 3 months. Cultures were carried out to isolate and identify *S aureus,* using a commercial kit. Susceptibility to methicillin was investigated by culture on screening agar. All strains were subjected to disc sensitivity testing for susceptibility to several antibiotics. Methicillin resistance was confirmed by DNA amplification of *mec*A on strains appearing resistant to oxacillin. To determine if the isolates from owner and dog were of the same strain, all paired isolates were typed by pulsed-field gel electrophoresis (PFGE). The relatedness of strains was determined by comparison of DNA band fragments. The study was approved by the respective Human and the Animal Subjects Ethics Committees of the Hong Kong Polytechnic University. The respective prevalence rates of colonisation were calculated and significant associations between categorical variables determined and rates of antibiotic resistance compared. Odds ratios were derived and significance testing for nasal carriage in humans and their dogs carried out by logistic regression.

Results

A total of 736 owners and 830 dogs were sampled for *S aureus* carriage. Some owners did not answer all questions in the questionnaire. *Staphylococcus aureus* was isolated from 174 (24%) of the humans and 73 (9%) of the dogs; in 17 pairs both parties were colonised (10% of the colonised humans). Approximately 89% of isolates were resistant to at least one antibiotic. *Staphylococcus aureus* strains from dogs tended to be more resistant than human isolates, with significantly higher resistance rates to several antibiotics including oxacillin. Antibiotic resistance patterns were similar in 11 pairs, suggesting both carried the same strain. These paired isolates were further investigated for relatedness using PFGE; four appeared identical.

The *mec*A gene was detected in four strains from humans and six from dogs, confirming the isolates as MRSA; one was from a dog-human pair. Carriage in humans was associated with an occupation related to health care (42% as opposed to 25% in non-HCWs) and either a cat or a bird in the household. All aspects of contact with their dogs were not associated with an increase in colonisation of the owners; colonisation was significantly more frequent in female (12%) than male dogs (6%), and in adults than puppies (<12 months old). The dog's size and antibiotic intake, and sex of the owner were not associated with carriage. Dogs of older owners were rarely colonised. Dogs in households with three or less persons were more likely to be colonised than in those with more occupants. Households with one to three dogs were less likely to have a colonised dog than those with more dogs. Colonisation of the owner was not associated with colonisation of the dog, but the dogs of HCWs were more likely to be colonised than those of others. Contact with the dog, including petting, carrying, and kissing or licking the face, did not increase the risk of colonisation. Sleeping in the bedroom was associated with increased colonisation of the dog, though this did not reach statistical significance. In small dogs, colonisation of the owner appeared to be a risk factor for colonisation of the dog, and access to the bedroom was more strongly associated with colonisation of the dog (Table). There was a trend for carriage associated with the age of the dog; there being more colonisation in older dogs (10%) compared to puppies (5%) and younger dogs (8%) [P=0.03].

Of the 17 colonised pairs, five owners were HCWs (P=0.001). Overall, 11% of HCWs were colonised along with their dogs, in comparison with only 2.3% of other professionals, 0.6% of clerical workers, 2% of artisans and 1.8% of students and housewives. Recent use of antibiotics in the dog reduced the chance of paired colonisation of both the owner and the dog (P=0.022).

One of the four MRSA-colonised owners was a HCW, as were the owners of two of the six MRSA-colonised dogs. Among MRSA-colonised dogs, five were female, and five were aged older than 4 years. Overall, 2.2% of human *S aureus* isolates were MRSA, representing a 0.5% colonisation rate in the community. In dogs, 8.2% of the isolates were MRSA, yielding a 0.7% overall carriage rate.

Discussion

This is the first study to investigate carriage of *S aureus* in dogs and their owners. The carriage rate in owners was similar to that described previously[1] and the colonisation rate in dogs was 8.8%, similar rates were also reported in limited studies of *S aureus* carriage in dogs.[3] The number of simultaneously colonised dogs and owners was low, with only 10% of colonised owners having a colonised dog. Clearly, many non-colonised owners had colonised dogs. The source of the organism may have been another household member, or a previous owner.

Antibiotic resistance was quite common, with almost 90% resistance rates to penicillin. For several antibiotics, resistance was significantly more likely in dogs than in humans, reflecting higher use of antibiotics in veterinary practice.[4] Resistance to two or more antimicrobials was detected in 54% of dog isolates and 44% of those from humans. A Canadian study of *S aureus* isolates from dogs reported that 67% were resistant to two or more antimicrobials.[3] High levels of tetracycline and fusidic acid resistance were noted in isolates from dogs. Fusidic acid is frequently used for skin and eye infections in dogs, and tetracyline for respiratory infections. Most antibiotic therapy in companion animals is empirical and pressure from owners may increase such usage.[4]

Previous studies have reported isolation of MRSA from infected dogs and case studies have shown that dogs

Table. Risk factors for carriage of *Staphylococcus aureus*

Variable	*S aureus* (%)		Odds ratio	Confidence interval	P value
	+ve	-ve			
Colonisation of owners					
Occupation					
Health care	19 (42)	26 (58)	2.2	1.19-4.09	0.001
Non–health care	151 (25)	455 (75)			
Other animals in the house					
None	135 (23)	441 (77)			0.001
Cat	20 (36)	36 (64)			
Bird	16 (48)	17 (52)			
Other	3 (13)	20 (87)			
Carrying dog					
Yes	161 (26)	468 (74)	1.470	0.744-2.03	0.265
Never	11 (19)	47 (81)			
Kiss dog					
Usually	48 (29)	120 (71)			0.408
Often	24 (21)	93 (79)			
Sometimes	78 (26)	225 (74)			
Never	22 (22)	77 (78)			
Colonisation of dogs					
Owner's occupation					
Health care	9 (20)	36 (80)	3.294	1.494-7.265	0.002
Non–health care	45 (7)	593 (93)			
No. in household					
1-3	43 (11)	365 (89)	1.475	1.005-2.165	0.027
>3	19 (6)	301 (94)			
No. of dogs in household					
1-3	53 (8)	619 (92)	0.496	0.256-0.962	0.04
>4	9 (16)	48 (84)			
Sex of dog					
Male	24 (6)	378 (94)	0.688	0.549-0.863	0.005
Female	36 (12)	266 (88)			
Dog has access to bedroom					
Yes	54 (9)	519 (91)	1.830	0.898-3.733	0.076
No	7 (5)	138 (95)			
Carrying dog					
Yes	58 (9)	605 (91)	1.294	0.453-3.701	0.630
No	4 (7)	54 (93)			
Kiss dog					
Usually	17 (10)	161 (90)			0.540
Often	13 (11)	107 (89)			
Sometimes	22 (7)	297 (93)			
Never	9 (9)	95 (91)			
Colonisation of small dogs					
No. dogs in household					
1-3	30 (8)	337 (92)	0.695	0.260-1.856	0.472
>4	4 (12)	30 (88)			
Dog has access to bedroom					
Yes	33 (10)	291 (90)	7.041	1.011-49.06	0.012
No	1 (1)	76 (99)			

belonging to infected patients can be colonised with MRSA, and even healthy dogs belonging to healthy non-colonised veterinary clinic staff can be colonised.[3]

Increased risk of colonisation of HCWs has been documented previously.[1] Working in clinical settings increases the risk of simple *S aureus* (including MRSA) colonisation. Interestingly, the presence of a cat or a bird also increased the risk of *S aureus* colonisation in humans; cleaning animal excreta in litter trays and cages may increase respiratory exposure to *S aureus* from animal faeces. The presence of multiple dogs in the household did not increase the likelihood of carriage in owners, nor did increased numbers of persons per household.

Close contact with companion animals is assumed to increase the likelihood of cross-infection, and people are advised to avoid animals licking their faces. Despite this, owners who admitted frequent close contact with their animals, including kissing the dog and allowing it to lick their face or sleep on their bed, were at no higher risk of colonisation with *S aureus* than those who did not.

Higher colonisation rates with *S aureus* in female dogs have been previously reported, possibly due to hormonal factors or behavioural differences between genders. Higher colonisation rates in households with multiple dogs may also be a result of different behaviours when other dogs are present, and the possibility of reduced hygiene standards. However, this did not extend to households with large numbers of small dogs; small pedigree dogs may be groomed more often, reducing the numbers of skin organisms.

The effect of age may be due to changes in the dog, but could reflect increased time of exposure. Colonisation in the dog was only associated with colonisation of the owner in the sub-set of small dogs, conceivably due to more frequent close contact, though kissing and petting were not significantly associated with carriage. Moreover, several small breeds (eg Pekinese and Shih Tzus) have brachycephaly and are more prone to nasal problems and inflammation, predisposing them to colonisation. However, the dogs of HCWs were at much higher risk of colonisation, regardless of size. Colonisation was noted in dogs of both currently colonised and non-colonised HCWs. Possibly HCWs carry the organism on their skin and clothing to which their dog is exposed, thus facilitating colonisation by dogs via transient skin carriage or even by non-carriers.

Access to the bedroom also increased risk of colonisation. Dressing, undressing, and bed-making sheds contaminated skin scales picked up by the dog. Colonised dogs of non-colonised owners may have acquired the *S aureus* from another household member, or may be persistently carrying a strain from a previous owner.

There were surprisingly few pairs of colonised owners and dogs. Although transient carriage may be the reason, it indicates transmission between owners and dogs may well be low. An occupation related to health care seemed to be the most important risk factor. Interestingly, use of antibiotics in the dog reduced the risk of colonisation; conceivably, antibiotic treatment for infection at another site eradicated the colonising strain. However, investigation of colonised 'pairs' showed that some carried differing strains, as only 11 pairs had similar antibiograms. Analysis of PFGE revealed that even if the antibiograms were identical, the pair of isolates were unrelated. In one case, both owner and dog were colonised with MRSA; PFGE indicated only four of the pairs were carrying identical strains, although 90% of owners claimed to be the person who had the most contact with the dog. Thus, though transfer between owner and dog, or vice versa, does occur, it may be more unusual than indicated by case reports. Although strains found in the dogs may have originated from other family members, other sources, in particular veterinary practices, may be involved in such transfers.[4]

Overall MRSA carriage rate was low, but notably one of the four MRSA-colonised humans was a HCW, whilst two of the six colonised dogs were owned by HCWs, emphasising the role of the latter in MRSA in the community. The transmission of MRSA to close contacts of HCWs has been previously documented,[2] implicating the dogs of HCWs as reservoirs. This study also confirmed that the dogs of HCWs were more easily colonised with MRSA. Although there was no obvious explanation why most MRSA-colonised dogs were female, perhaps HCWs should be encouraged to select a male dog.

Dogs as reservoirs for *S aureus* (particularly MRSA), following increased levels of colonisation, has been a concern particularly as levels of MRSA continue to increase in the community, notably in the US and Australia.[2] Locally, though levels of MRSA in the community remain low[5]—vigilance is advised as Hong Kong has recently reported infections with CA-MRSA strains.[6] Whilst this study investigated the association between colonisation and close contact between companion animals and their owners in broad terms, its setting in Hong Kong (an urbanised, densely populated area) conveniently assessed such contact at an extreme level.

Conclusion

Colonisation of dogs is primarily associated with the owner's occupation, and dog ownership is unlikely to significantly increase the risk of infection in healthy subjects. Close contact with dogs was not associated with an increased risk of colonisation of either the owner or dog. However, companion animals may serve as a reservoir for infecting the immunocompromised. As dogs of HCWs are more likely to be colonised, consideration should be given to de-colonisation of corresponding dogs. The major route of transmission is from owner to dog, but a two-way process is possible. The actual patterns of transmission can only be confirmed by a larger longitudinal study.

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