Veterinary Dermatology

Vet Dermatol 2021; **32**: 668–e178 DOI: 10.1111/vde.12975

Influence of hospital size on antimicrobial resistance and advantages of restricting antimicrobial use based on cumulative antibiograms in dogs with *Staphylococcus pseudintermedius* infections in Japan

Keita Iyori*, Taku Shishikura†, Kenta Shimoike*, Kenichi Minoshima*, Ichiro Imanishi‡ and Yoichi Toyoda*

*Vet Derm Tokyo, Dermatological and Laboratory Service for animals, 910 Shoubusawa, Fujisawa-shi, Kanagawa 252-0823, Japan
†Daktari Animal Hospital Tokyo Medical Center, 5-14-1 Shirokanedai, Minato-ku, Tokyo, Japan
‡Department of Microbiology, Kitasato University School of Medicine, 1-15-1 Kitasato, Minami-ku, Sagamihara, Kanagawa 252-0374, Japan

Correspondence: Keita Iyori, Vet Derm Tokyo, Dermatological and Laboratory Service for animals, 910 Shoubusawa, Fujisawa-shi, Kanagawa 252-0823, Japan. E-mail: iyori@vdt.co.jp

Background – Antimicrobial resistance in *Staphylococcus pseudintermedius* (SP) and the prevalence of meticillin-resistant SP (MRSP) is increasing in dogs worldwide.

Objectives – To evaluate the influence of hospital size on antimicrobial resistance of SP and whether restricted use of antimicrobials based on antibiograms could reduce the identification of antimicrobial resistance in SP from infected dogs.

Methods and materials – In Study 1, a total of 2,294 SP isolates from dogs with pyoderma (n = 1,858, 52 hospitals) or otitis externa (OE; n = 436, 44 hospitals) taken between 2017 and 2019 were analysed. Clinics were categorised into small, medium and large based on numbers of practicing veterinary surgeons. In Study 2, a cumulative antibiogram was constructed for 12 antimicrobials from one large veterinary clinic from 2017 to 2018. Referring to this antibiogram, the clinic introduced strict antimicrobial selection criteria to treat dogs with pyoderma and OE, starting in 2018.

Results – MRSP was identified in 981 dogs (42.8%). In large clinics, the isolation rate of MRSP was 51.1% (404 of 791), which was significantly higher ($P < 0.01$) than in small clinics with less than two veterinary practitioners (34.0%, 154 of 453). In the antibiogram study, the susceptibility rates of oxacillin (MPIPC, 61.5%), cefpodoxime (CPDX, 55.8%) and minocycline (MINO, 55.8%) were significantly higher in 2019 (n = 52) than in 2017 to 2018 (n = 54; MPIPC, 37.0%; CPDX, 33.3%; MINO, 20.4%; $P < 0.05$).

Conclusions and clinical relevance – Hospital size could affect the isolation rate of MRSP in dogs. Restricted use of antimicrobials for over a year based on cumulative antibiograms could reduce the resistance rate of multiple antimicrobials in SP isolated from dogs with pyoderma and OE.

Introduction

Canine pyoderma and otitis externa (OE) are among the most common diseases encountered in veterinary practice.[1–6] *Staphylococcus pseudintermedius* (SP) is a commensal and common bacterial pathogen in dogs with pyoderma and OE.[7–9] In recent years, SP has gained considerable attention because of the emergence of antimicrobial resistance of SP and meticillin-resistant SP (MRSP) in dogs worldwide.[10–12] MRSP expresses the penicillin-binding protein 2a, encoded by the *mecA* gene, and shows low affinity to all β-lactam antimicrobials, including cephalosporins and carbapenems.[13] In Japan, the isolation of MRSP in dogs was not reported until 2000.[14,15] Since then, MRSP has been reported in dogs with pyoderma or OE in several regions in Japan; however, the isolation rates of MRSP have varied greatly depending on the research areas and institutions.[14–19]

Because MRSP isolates often are resistant not only to β-lactams, but also to several other classes of antimicrobial drugs, the treatment of MRSP infection in dogs has been a challenge in veterinary medicine.[20] The recommendations for MRSP infections in small animals by the Clinical Consensus Guidelines of the World Association for Veterinary Dermatology state that restriction policies for certain antimicrobial drugs might help to mitigate the progressive development and dissemination of multidrug-resistant staphylococci.[10] Recent studies in Japan revealed that the restricted use of antimicrobials for over a period of approximately two years, especially the use of third-generation cephalosporins and fluoroquinolones, was effective in reducing antimicrobial resistance rates in the *Staphylococcus intermedius* group, including MR

Accepted 13 February 2021
Sources of Funding: This study was self-funded.
Conflicts of Interest: No conflicts of interest have been declared.

strains, and *Escherichia coli* isolated from diseased dogs in an animal hospital.[21]

A cumulative antibiogram is a periodic summary of the test results of the antimicrobial susceptibility of specific micro-organisms to batteries of antimicrobial drugs during a specific period of time (e.g. 12 months).[22] Cumulative antibiograms are used to select appropriate empirical antimicrobial treatments and monitor the trends of antimicrobial resistance. In humans, the use of hospital cumulative antibiograms to guide the choice of empirical antimicrobial therapy has been identified as a key strategy to prevent and control the spread of antimicrobial-resistant micro-organisms in hospitals.[23,24]

The influence of hospital size on meticillin resistance or the antimicrobial susceptibility pattern is unclear in SP isolated from dogs with pyoderma and OE. Moreover, only a few studies have evaluated the usefulness of antibiograms to establish the criteria for antimicrobial restriction in small animal practices.[25] One objective of this study was to investigate the antimicrobial resistance pattern of SP in infected dogs from animal hospitals in Japan categorized into three different sizes based on numbers of practicing veterinary surgeons. The other objective was to evaluate whether the restricted use of antimicrobials based on cumulative antibiograms could reduce the frequency of resistance of several types of antimicrobials in clinical SP isolates from dogs with pyoderma and OE.

Materials and methods

Ethics

This study was conducted in compliance with applicable animal welfare regulations relating to the care and use of animals for scientific purposes.[26] The study was conducted in accordance with good clinical practice guidelines,[27] and informed consent was obtained from the owner of each participating dog.

Study design

This study analysed the antimicrobial resistance patterns of SP isolates from lesions of dogs with pyoderma or OE in different animal hospitals (Study 1), and evaluated the usefulness of restricting antimicrobial use based on an antibiogram for SP infections in dogs (Study 2).

Study 1: Analysis of antimicrobial resistance patterns of SP isolates from different animal hospitals

Bacterial samples and animal hospitals

Samples of SP were obtained from 2,294 dogs with pyoderma or OE that were treated in our affiliated veterinary clinics between 1 January 2017 and 31 December 2019. These samples were collected initially for bacterial culture and susceptibility testing by a commercial diagnostic bacteriology laboratory service. The samples were stored in Luria–Bertani broth (Sigma-Aldrich Corp.; St Louis, MO, USA) with 10% glycerol at −80°C until further use. Pyoderma or OE had been confirmed by the attending veterinary surgeons based on clinical signs, cytological findings and bacterial culture. There were 1,858 SP isolates from pyoderma from 52 veterinary clinics and 436 from OE from 44 veterinary clinics in 17 cities (Hokkaido, Miyagi, Fukushima, Tokyo, Kanagawa, Chiba, Saitama, Ibaraki, Shizuoka, Aichi, Gifu, Nara, Kyoto, Osaka, Hyogo, Okayama and Hiroshima). The veterinary clinics were categorized into three sizes: large clinics with >10, medium clinics with three to nine, and small clinics with two or fewer practising veterinary surgeons.

Species identification

Each swab (Seed Swab TechnoAmenity Inc.; Kyoto, Japan) was inoculated onto 5% sheep blood agar (Eiken Chemical Co., Ltd; Tokyo, Japan) and/or mannitol salt agar (Eiken Chemical Co., Ltd) and incubated aerobically at 37°C for 18–24 h. Identification of SP was determined by colony morphology, the ability to grow on mannitol salt agar, Gram-stain characteristics, coagulase reaction and multiplex-polymerase chain reaction (multiplex-PCR), which was performed with thermonuclease genes using a primer pair reported previously.[28] Crude DNA for PCR was extracted with achromopeptidase (Wako Chemical Co. Ltd.; Osaka, Japan), as described previously.[28]

Antimicrobial susceptibility testing and identification of MRSP

Antimicrobial susceptibility analyses were carried out on SP isolates by the disk diffusion susceptibility test using the KB disk (Eiken Chemical Co., Ltd.) according to the Clinical and Laboratory Standards Institute (CLSI) guidelines.[29-31] The following commonly used drug classes in Japan were tested: oxacillin (MPIPC, 1 μg/disk), clavulanic acid-amoxicillin (AMPC/CVA, 20 μg/10 μg/disk), cefalexin (CEX; 30 μg/disk), cefpodoxime (CPDX; 10 μg/disk), enrofloxacin (ERFX; 5 μg/disk), gentamicin (GM; 10 μg/disk), trimethoprim-sulfamethoxazole (ST; 23.75 μg-1.25 μg/disk), clindamycin (CLDM; 2 μg/disk), doxycycline (DOXY; 30 μg/disk), minocycline (MINO; 30 μg/disk), chloramphenicol (CP; 30 μg/disk) and fosfomycin (FOM; 50 μg/disk). In the disk diffusion testing, the interpretative criteria for susceptible (S), intermediate (I) or resistant (R), were taken from: the CLSI VET08[30] for MPIPC, CPDX and DOXY; the CLSI M100-S30[31] for AMPC/CVA, ERFX, GM, ST, CLDM, MINO and CP; and the KB disk standard of *Staphylococcus* spp. for CEX and FOM. MRSP was identified with MPIPC disk (1 μg/disk) diffusion testing according to CLSI guidelines.[29]

Study 2: Evaluation of the usefulness of restricting antimicrobials use with an antibiogram for SP infections in dogs

A cumulative antibiogram was constructed for all isolates collected from one large clinic (Tokyo) between 1 January 2017 and 31 September 2018 for 12 antimicrobial agents, including MPIPC, AMPC/CVA, CPDX, ERFX, GM, ST, CLDM, DOXY, MINO, CP and FOM according to the CLSI guidelines.[22] The methods for disk diffusion testing were as described above. The CLSI guidelines recommend compiling the antibiogram at least annually, including only the first isolate per case in the period analysed, as well as only organisms for which ≥30 isolates were tested in the period analysed. The susceptibility rate of each antimicrobial was calculated based on the number of susceptible isolates, not including intermediate isolates. Based on the results of an antibiogram from 2017 to 2018, veterinary clinics introduced strict antimicrobial prescribing criteria starting on 1 November 2018 for the treatment of dogs with pyoderma or OE. Furthermore, the clinics preferred topical antimicrobial treatments, such as 0.5–2% chlorhexidine lotion or shampoo, and antimicrobial ear drops or cleaner, over systemic antimicrobial treatment. Following the restricted use of antimicrobials for over a year, a cumulative antibiogram was reconstructed using the susceptibility test data between 1 January 2019 and 31 December 2019.

Statistical analysis

Antimicrobial susceptibility patterns from different clinic sizes were analysed using a logistic regression equation. The susceptibility patterns before and after antimicrobial restriction with an antibiogram in a large veterinary clinic were analysed using the Chi-square test. STATVIEW software (v.5.0, Hulinks; Tokyo, Japan) was used for both

Table 1. Antimicrobial susceptibility test results of *Staphylococcus pseudintermedius* isolated from dogs with pyoderma according to veterinary clinic size

	Small (n = 356)			Medium (n = 886)		
Number of SP isolates (%)	R	I	S	R	I	S
MPIPC	124 (34.8%)	0 (0.0%)	232 (65.2%)	358 (40.4%)	0 (0.0%)	528 (59.6%)
AMPC/CVA	44 (12.4%)	0 (0.0%)	312 (87.6%)	126 (14.2%)	0 (0.0%)	760 (85.8%)
CEX	79 (22.2%)	19 (5.3%)	258 (72.5%)	217 (24.5%)	39 (4.4%)	630 (71.1%)
CPDX	111 (32.9%)	22 (6.5%)	204 (60.5%)	298 (34.3%)	83 (9.6%)	487 (56.1%)
ERFX	204 (57.3%)	21 (5.9%)	131 (36.8%)	521 (58.8%)	43 (4.9%)	322 (36.3%)
GM	120 (35.6%)	30 (8.9%)	187 (55.5%)	314 (36.2%)	72 (8.3%)	482 (55.5%)
ST	140 (40.7%)	19 (5.5%)	185 (53.8%)	307 (43.5%)	41 (5.8%)	358 (50.7%)
CLDM	182 (52.9%)	32 (9.3%)	130 (37.8%)	403 (57.1%)	63 (8.9%)	240 (34.0%)
DOXY	204 (60.5%)	28 (8.3%)	105 (31.2%)	548 (63.1%)	48 (5.5%)	272 (31.3%)
MINO	41 (12.2%)	120 (35.6%)	176 (52.2%)	87 (9.8%)	355 (40.2%)	442 (50.0%)
CP	98 (29.1%)	38 (11.3%)	201 (59.6%)	238 (27.4%)	131 (15.1%)	499 (57.5%)
FOM	17 (5.0%)	26 (7.7%)	294 (87.2%)	83 (9.6%)	52 (6.0%)	733 (84.4%)

	Large (n = 616)			Total (n = 1,858)		
Number of SP isolates (%)	R	I	S	R	I	S
MPIPC	307 (49.8%)	0 (0.0%)	309 (50.2%)	789 (42.5%)	0 (0.0%)	1069 (57.5%)
AMPC/CVA	137 (22.2%)	0 (0.0%)	479 (77.8%)	307 (16.5%)	0 (0.0%)	1551 (83.5%)
CEX	209 (33.9%)	37 (6%)	370 (60.1%)	505 (27.2%)	95 (5.1%)	1258 (67.7%)
CPDX	272 (45.8%)	54 (9.1%)	268 (45.1%)	681 (37.9%)	159 (8.8%)	959 (53.3%)
ERFX	445 (72.2%)	24 (3.9%)	147 (23.9%)	1,170 (63%)	88 (4.7%)	600 (32.3%)
GM	245 (41.2%)	85 (14.3%)	264 (44.4%)	679 (37.7%)	187 (10.4%)	933 (51.9%)
ST	271 (49.9%)	29 (5.3%)	243 (44.8%)	718 (45.1%)	89 (5.6%)	786 (49.3%)
CLDM	364 (67.2%)	49 (9.0%)	129 (23.8%)	949 (59.6%)	144 (9.0%)	499 (31.3%)
DOXY	414 (69.8%)	24 (4.0%)	155 (26.1%)	1,166 (64.8%)	100 (5.6%)	532 (29.6%)
MINO	85 (13.9%)	292 (47.7%)	235 (38.4%)	213 (11.6%)	767 (41.8%)	853 (46.5%)
CP	204 (34.4%)	116 (19.6%)	273 (46.0%)	540 (30.0%)	285 (15.9%)	973 (54.1%)
FOM	51 (8.6%)	51 (8.6%)	491 (82.8%)	151 (8.4%)	129 (7.2%)	1,518 (84.4%)

SP, *Staphylococcus pseudintermedius*; MPIPC, oxacillin; AMPC/CVA, clavulanic acid-amoxicillin; CEX, cefalexin; CPDX, cefpodoxime; ERFX, enrofloxacin; GM, gentamycin; ST, trimethoprim-sulfamethoxazole; CLDM, clindamycin; DOXY, doxycycline; MINO, minocycline; CP, chloramphenicol; FOM, fosfomycin.

statistical analyses. A *P*-value < 0.05 was considered statistically significant.

Results

Study 1

Tables 1 and 2 show the antimicrobial susceptibility testing results of SP isolated from dogs with pyoderma or OE in veterinary clinics of different sizes. The isolation rate of MRSP with the MPIPC disk diffusion test in large clinics was 51.1% (404 of 791), which was significantly higher ($P < 0.01$) than that in the small (34.0%, 154 of 453) and medium clinics (40.3%, 423 of 1,050; Table 3). Each susceptibility rate of AMPC/CVA, CEX, CPDX, ERFX, GM, ST, CLDM, MINO and CP in pyoderma, and that of CEX, CPDX, ERFX, ST, CLDM, CP and FOM in OE, was significantly higher in small clinics than in large clinics ($P < 0.05$; Table 3). Each susceptibility rate of MPIPC, AMPC/CVA, CEX, CPDX, ERFX, GM, ST CLDM, DOXY, MINO and CP in pyoderma, and that of MPIPC, AMPC/CVA, CEX, CPDX and ERFX in OE, was significantly higher in medium clinics than in large clinics ($P < 0.05$; Table 3). No antimicrobials used in both small and medium clinics had significantly lower susceptibility than those used in large clinics. There were no significant differences in the susceptibility rates of all tested antimicrobials in pyoderma between small and medium clinics. The susceptibility rates of CPDX and CLDM in OE were significantly higher in small clinics than in medium and large clinics ($P < 0.05$; Table 3).

Study 2

From 2017 to 2018, 54 SP isolates were collected from dogs with pyoderma (n = 30) and OE (n = 24). The resulting cumulative antibiogram from 2017 to 2018 showed the following susceptibility rates (in ascending order): DOXY (14.8%), CLDM (16.7%), ERFX (18.5%), MINO (20.4%), ST (31.5%), CPDX (33.3%), MPIPC (37.0%), GM (40.7%), CEX (50.0%), CP (50.0%), FOM (57.4%) and AMPC/CVA (66.7%).

Based on these results, the large veterinary clinic introduced strict antimicrobial prescribing criteria to treat dogs with pyoderma and OE, which included the following: (i) systemic treatments with fluoroquinolones and β-lactam antimicrobials, including first- and third-generation cephalosporins should be used only when life-threatening infection is expected; (ii) CP and FOM could be used for empirical treatment; and (iii) ST, CLDM, DOXY and MINO should be used according to the results of susceptibility tests. Following the restricted use of antimicrobials, a cumulative antibiogram was reconstructed using the susceptibility test data between 1 January and 31 December 2019. A total of 52 SP strains were isolated from dogs with pyoderma (n = 30) and OE (n = 22). Although the frequency of susceptibility was higher for all antimicrobials in 2019 compared to 2017 to 2018, with the exception of ST,

Table 2. Antimicrobial susceptibility test results of *Staphylococcus pseudintermedius* isolated from dogs with otitis externa according to veterinary clinic size

	Small (n = 97)			Medium (n = 164)		
Number of SP isolates (%)	R	I	S	R	I	S
MPIPC	30 (30.9%)	0 (0.0%)	67 (69.1%)	65 (39.6%)	0 (0.0%)	99 (60.4%)
AMPC/CVA	15 (15.5%)	0 (0.0%)	82 (84.5%)	24 (14.6%)	0 (0.0%)	140 (85.4%)
CEX	16 (16.5%)	4 (4.1%)	77 (79.4%)	38 (23.2%)	14 (8.5%)	112 (68.3%)
CPDX	21 (21.6%)	9 (9.3%)	67 (69.1%)	61 (37.2%)	16 (9.8%)	87 (53%)
ERFX	60 (61.9%)	7 (7.2%)	30 (30.9%)	112 (68.3%)	12 (7.3%)	40 (24.4%)
GM	35 (36.1%)	12 (12.4%)	50 (51.5%)	74 (45.1%)	21 (12.8%)	69 (42.1%)
ST	41 (42.3%)	6 (6.2%)	50 (51.5%)	83 (51.6%)	9 (5.6%)	69 (42.9%)
CLDM	46 (56.1%)	5 (6.1%)	31 (37.8%)	103 (70.5%)	10 (6.8%)	33 (22.6%)
DOXY	66 (68.0%)	8 (8.2%)	23 (23.7%)	105 (64%)	8 (4.9%)	51 (31.1%)
MINO	14 (20.0%)	27 (38.6%)	29 (41.4%)	20 (19.8%)	28 (27.7%)	53 (52.5%)
CP	23 (23.7%)	17 (17.5%)	57 (58.8%)	68 (41.5%)	18 (11.0%)	78 (47.6%)
FOM	7 (7.2%)	7 (7.2%)	83 (85.6%)	16 (9.8%)	16 (9.8%)	132 (80.5%)
	Large (n = 175)			Total (n = 436)		
Number of SP isolates (%)	R	I	S	R	I	S
MPIPC	97 (55.4%)	0 (0.0%)	78 (44.6%)	192 (44%)	0 (0.0%)	244 (56.0%)
AMPC/CVA	41 (23.4%)	0 (0.0%)	134 (76.6%)	80 (18.3%)	0 (0.0%)	356 (81.7%)
CEX	61 (34.9%)	22 (12.6%)	92 (52.6%)	115 (26.4%)	40 (9.2%)	281 (64.4%)
CPDX	90 (51.4%)	12 (6.9%)	73 (41.7%)	172 (39.4%)	37 (8.5%)	227 (52.1%)
ERFX	137 (78.3%)	11 (6.3%)	27 (15.4%)	309 (70.9%)	30 (6.9%)	97 (22.2%)
GM	73 (41.7%)	29 (16.6%)	73 (41.7%)	182 (41.7%)	62 (14.2%)	192 (44.0%)
ST	110 (62.9%)	6 (3.4%)	59 (33.7%)	234 (54.0%)	21 (4.8%)	178 (41.1%)
CLDM	138 (78.9%)	4 (2.3%)	33 (18.9%)	287 (71.2%)	19 (4.7%)	97 (24.1%)
DOXY	125 (71.4%)	12 (6.9%)	38 (21.7%)	296 (67.9%)	28 (6.4%)	112 (25.7%)
MINO	27 (26.0%)	34 (32.7%)	43 (41.3%)	61 (22.2%)	89 (32.4%)	125 (45.5%)
CP	68 (38.9%)	30 (17.1%)	77 (44.0%)	159 (36.5%)	65 (14.9%)	212 (48.6%)
FOM	35 (20.0%)	14 (8.0%)	126 (72.0%)	58 (13.3%)	37 (8.5%)	341 (78.2%)

SP, *Staphylococcus pseudintermedius*; MPIPC, oxacillin; AMPC/CVA, clavulanic acid-amoxicillin; CEX, cefalexin; CPDX, cefpodoxime; ERFX, enrofloxacin; GM, gentamycin; ST, trimethoprim-sulfamethoxazole; CLDM, clindamycin; DOXY, doxycycline; MINO, minocycline; CP, chloramphenicol; FOM, fosfomyci.

these differences were significant only for MPIPC (61.5%, $P = 0.02$), CPDX (55.8%, $P = 0.03$) and MINO (55.8%, $P = 0.001$), as shown in Table 4.

Discussion

This study investigated the influence of hospital size (number of practising veterinary surgeons) on the antimicrobial resistance of SP, and determined whether the restricted use of antimicrobials with antibiograms could reduce the antimicrobial resistance of SP in infected dogs. Study 1 included a total of 2,294 SP isolates from 17 cities in Japan. Previous Japanese studies analysed 31 to 282 strains of SP in dogs.[14–19] To the best of the authors' knowledge, the present study used the largest number of SP strains isolated from dogs with pyoderma and OE in Japan. Previous reports revealed that the antimicrobial susceptibility patterns of MRSP differed between North America and Europe, which indicates differences in the susceptibility patterns between different MRSP clones across different countries.[9] Although the present study revealed that the isolation rate of MRSP was 42.8% in total, the isolation rates of MRSP varied greatly (11.4–69.1%) depending on the research year (2007–2014), area and institution (private clinic or referral clinic) according to previous Japanese studies.[14–19]

Two studies performed in referral clinics showed higher isolation rates of MRSP in dogs with pyoderma (2007–2009: 66.5%; 2010: 57%)[16,17] than those in a study performed in 11 animal hospitals (2009: 11.4%).[15] Our study showed that the susceptibility rates of several classes of antimicrobials in SP isolated from dogs with pyoderma or OE were significantly lower in large veterinary clinics than in small and medium clinics. Furthermore, the isolation rate of MRSP was significantly higher in large clinics than in small and medium clinics. These findings indicate that the number of practising veterinary surgeons in a clinic could influence the antimicrobial resistance of SP in dogs.

A significant correlation between antimicrobial resistance and consumption of antimicrobials for *S. aureus* has been reported.[32] Although the present study did not confirm the antimicrobial consumption in each clinic, or the medical history in each case, it was presumed that large veterinary clinics or referral clinics would use larger amounts of antimicrobials and have a larger number of recurrent cases than smaller clinics.

It has been reported that patterns of antimicrobial use could influence the antimicrobial resistance of *S. aureus* in humans.[33,34] For appropriate antimicrobial use, two guidelines were created independently in North America and the European Union in 2013 to 2014 for the antimicrobial treatment of canine skin diseases.[35–37] However, these guidelines are not relevant to particular countries. There are no guidelines on the antimicrobial treatment of

Table 3. Comparisons between small, medium and large clinics for antimicrobial susceptibility rates in *Staphylococcus pseudintermedius* isolated from dogs affected with pyoderma or otitis externa

	Pyoderma								
	Small (versus Large)			Medium (versus Small)			Medium (versus Large)		
	OR	95% CI	*P*-value	OR	95% CI	*P*-value	OR	95% CI	*P*-value
MPIPC	1.86	1.42–2.44	<0.001*	0.79	0.61–1.02	0.07	1.47	1.19–1.8	<0.001*
AMPC/CVA	2.03	1.41–2.96	<0.001*	0.85	0.58–1.22	0.39	1.73	1.32–2.26	<0.001*
CEX	1.75	1.32–2.33	<0.001*	0.93	0.71–1.23	0.63	1.64	1.32–2.03	<0.001*
CPDX	1.87	1.42–2.45	<0.001*	0.83	0.64–1.08	0.16	1.55	1.26–1.92	<0.001*
ERFX	1.86	1.4–2.47	<0.001*	0.98	0.76–1.27	0.88	1.82	1.45–2.3	<0.001*
GM	1.56	1.19–2.04	<0.001*	1	0.78–1.29	0.99	1.56	1.27–1.93	<0.001*
ST	1.44	1.1–1.89	0.01*	0.88	0.68–1.14	0.35	1.27	1.01–1.59	0.04*
CLDM	1.94	1.45–2.61	<0.001*	0.85	0.65–1.11	0.23	1.65	1.28–2.12	<0.001*
DOXY	1.28	0.95–1.72	0.10	1.01	0.77–1.33	0.95	1.29	1.02–1.63	0.03*
MINO	1.75	1.34–2.3	<0.001*	0.91	0.71–1.18	0.49	1.6	1.3–1.98	<0.001*
CP	1.73	1.32–2.27	<0.001*	0.91	0.71–1.18	0.5	1.59	1.29–1.96	<0.001*
FOM	1.42	0.97–2.1	0.07	0.79	0.54–1.14	0.22	1.13	0.85–1.49	0.40
	Otitis externa								
	Small (versus Large)			Medium (versus Small)			Medium (versus Large)		
	OR	95% CI	*P*-value	OR	95% CI	*P*-value	OR	95% CI	*P*-value
MPIPC	2.78	1.66–4.73	<0.001*	0.68	0.4–1.16	0.16	1.89	1.23–2.93	0.01*
AMPC/CVA	1.67	0.89–3.3	0.12	1.07	0.52–2.13	0.86	1.78	1.03–3.15	0.04*
CEX	3.47	1.99–6.29	<0.001*	0.56	0.3–1	0.05	1.94	1.25–3.04	<0.001*
CPDX	3.12	1.86–5.33	<0.001*	0.51	0.3–0.85	0.01*	1.58	1.03–2.43	0.04*
ERFX	2.45	1.36–4.47	<0.001*	0.72	0.41–1.27	0.25	1.77	1.03–3.07	0.04*
GM	1.49	0.9–2.45	0.12	0.68	0.41–1.13	0.14	1.01	0.66–1.56	0.95
ST	2.09	1.26–3.48	<0.01*	0.71	0.42–1.17	0.18	1.47	0.95–2.3	0.09
CLDM	2.62	1.46–4.71	<0.001*	0.48	0.27–0.87	0.02*	1.26	0.73–2.17	0.41
DOXY	1.12	0.62–2.01	0.71	1.45	0.83–2.61	0.2	1.63	1.0–2.66	0.05
MINO	1	0.54–1.86	0.99	1.56	0.85–2.91	0.16	1.57	0.9–2.73	0.11
CP	1.81	1.1–3.01	0.02*	0.64	0.38–1.05	0.08	1.15	0.75–1.77	0.51
FOM	2.31	1.22–4.58	<0.001*	0.70	0.34–1.36	0.30	1.60	0.97–2.68	0.07

MPIPC, oxacillin; AMPC/CVA, clavulanic acid-amoxicillin; CEX, cefalexin; CPDX, cefpodoxime; ERFX, enrofloxacin; GM, gentamycin; ST, trimethoprim-sulfamethoxazole; CLDM, clindamycin; DOXY, doxycycline; MINO, minocycline; CP, chloramphenicol; FOM, fosfomyci; OR; odds ratio, CI; confidence interval.
*P < 0.05.

Table 4. Results of antibiograms from *Staphylococcus pseudintermedius* isolated from dogs affected with pyoderma and otitis externa before (2017–2018) and after (2019) the restriction of antimicrobial use

	2017–2018		2019		
Number of SP isolates (%)	n	%	n	%	*P*-value
Total	54	100.0	52	100.0	
MPIPC	20	37.0	32	61.5	0.02*
AMPC/CVA	36	66.7	41	78.8	0.23
CEX	27	50.0	35	67.3	0.11
CPDX	18	33.3	29	55.8	0.03*
ERFX	10	18.5	15	28.8	0.31
GM	22	40.7	30	57.7	0.10
ST	17	31.5	14	26.9	0.76
CLDM	9	16.7	15	28.8	0.21
DOXY	8	14.8	15	28.8	0.13
MINO	11	20.4	29	55.8	0.001*
CP	27	50.0	30	57.7	0.34
FOM	31	57.4	32	61.5	0.63

SP, *Staphylococcus pseudintermedius*; MPIPC, oxacillin; AMPC/CVA, clavulanic acid-amoxicillin; CEX, cefalexin; CPDX, cefpodoxime; ERFX, enrofloxacin; GM, gentamycin; ST, trimethoprim-sulfamethoxazole; CLDM, clindamycin; DOXY, doxycycline; MINO, minocycline; CP, chloramphenicol; FOM, fosfomycin
*$P < 0.05$.

pyoderma and OE in dogs in Japan. The Guideline Committee of the Japanese Society of Veterinary Dermatology stated that it was difficult to propose a guideline for Japanese practitioners in 2017, because evidence for the practice was quite limited.[38] The lack of guidelines leads to an inconsistent selection of antimicrobials by veterinary practitioners, which may contribute to an increase in resistant strains, especially in large veterinary clinics.

In Study 2, the restricted, antibiogram-based use of antimicrobials significantly improved the susceptibility rate of MPIPC (37.0–61.5%) and CPDX (33.3–55.8%). We restricted the systemic use of fluoroquinolones and β-lactam antimicrobials, including first- and third-generation cephalosporins, as well as AMPC/CVA, which showed the highest susceptibility rate (66.7%) before restriction in this study. The susceptibility to MPIPC was low (37.0%) from 2017 to 2018, indicating a high prevalence of MRSP. For *S. aureus*, it has been reported that the use of fluoroquinolones and β-lactam antimicrobials is a risk factor for meticillin resistance.[32] A previous study indicated the importance of fluoroquinolones in promoting the survival and spread of multidrug-resistant MRSP.[39] Furthermore, the restriction of antimicrobials –

mainly, third-generation cephalosporins and fluoroquinolones – reduced the isolation rate of the MR *S. intermedius* group from 41.5% to 9.3%.[21]

These findings suggest that the restriction of fluoroquinolones and β-lactam antimicrobials for over a year could be useful in reducing the meticillin resistance rate of SP in dogs. The susceptibility rate of ERFX increased slightly from 18.5% to 28.8% and was not significantly changed in the present study. In a previous study, from 2016, the use of fluoroquinolones in the treatment of *S. intermedius* infections in dogs and cats was restricted; subsequently, the resistance rate of ERFX was significantly decreased in 2017 (39.0%) and 2018 (22.2%) compared to that in 2015 (59.4%).[21] In the present study, the resistance rate of ERFX in SP isolates before the restriction was 81.5% (2017 to 2018), which was higher than that reported previously. Although further studies are needed to confirm the change in fluoroquinolone resistance after antimicrobial use restriction, the high resistance rate of ERFX and short duration of antimicrobial restriction could influence the recovery of fluoroquinolone resistance in SP.

Cumulative antibiograms help establish the criteria for empirical systemic treatment with antimicrobials in each hospital. However, in the treatment of canine OE, topical antimicrobial therapy is commonly used in small animal practices. The large hospital enrolled in this study usually has chronic severe or referral cases of canine OE that require systemic antimicrobial treatment. Therefore, our study analysed and established antibiograms for both pyoderma and OE. The antimicrobials that show a high susceptibility rate (>80%) in antibiograms are commonly recommended for empirical use. However, there were no antimicrobials with a susceptibility rate >80% in the present study. Therefore, we recommend the use of topical antiseptic therapy, especially chlorhexidine lotion or shampoo products for pyoderma, and antimicrobial ear drops or cleaner for OE, before systemic antimicrobial treatment, as much as possible. Previous reports showed that a twice-weekly chlorhexidine shampoo combined with daily chlorhexidine spray was as effective as oral AMPC/CVA for treatment in dogs with pyoderma, including MRSP infection.[40] A Japanese study revealed that the minimal inhibitory concentration (MIC) for chlorhexidine remained low, and that there were no significant differences in the MIC of chlorhexidine between *mecA*-positive and *mecA*-negative SP isolated from dogs with pyoderma.[17] After the restriction of systemic antimicrobial treatment and the recommendation of topical treatment, MINO revealed a significant elevation in susceptibility rate (from 20.4% to 55.8%), while other classes of antimicrobials did not show a significant decrease in susceptibility rates in the present study. Although this study did not investigate the detailed use of each antimicrobial, topical treatment with antiseptics may be used as an alternative to antimicrobial use in veterinary clinics to prevent the resistance of SP, if systemic antimicrobials with susceptible rates >80% cannot be used based on the results of antibiograms in dogs.

Conclusions

In summary, antimicrobial resistance, including meticillin resistance in SP, may be influenced by the number of veterinary practitioners in the clinic. The restricted use of antimicrobials for over a year, based on antibiograms, reduced the rate of antimicrobial resistance of SP strains, including MRSP isolated from dogs with pyoderma and OE. Although the number of dogs is gradually decreasing in Japan, the estimated sale of antimicrobials has been increasing in recent years.[36] It is important to select and restrict antimicrobials and to create antibiograms regularly at each veterinary clinic to prevent future antimicrobial resistance in dogs.

References

1. Scott DW, Paradis MA. Survey of canine and feline skin disorders seen in a university practice: Small animal clinic, University of Montreal, Saint-Hyacinthe, Quebec (1987–1988). *Can Vet J* 1990; 31: 830–835.
2. Hill PB, Lo A, Eden CAN, et al. Survey of the prevalence, diagnosis and treatment of dermatological conditions in small animals in general practice. *Vet Rec* 2006; 158: 533–539.
3. Sischo WM, Ihrke PJ, Franti CE. Regional distribution of ten common skin diseases in dogs. *J Am Vet Med Assoc* 1989; 195: 752–756.
4. Lund EM, Armstrong PJ, Kirk CA. Health status and population characteristics of dogs and cats examined at private veterinary practices in United States. *J Am Vet Med Assoc* 1999; 214: 1,336–1,341.
5. Neill DG, Church DB, McGreevy PD, et al. Prevalence of disorders recorded in dogs attending primary-care veterinary practice in England. *PLoS One* 2014; 9: e90501.
6. Kim E, Chie C, Yoo JG, et al. Major medical causes by breed and life stage for dogs presented at veterinary clinics in the Republic of Korea: a survey of electronic medical records. *PeerJ* 2018; 6: e5161.
7. Bannoehr J, Guardabassi L. *Staphylococcus pseudintermedius* in the dog: taxonomy, diagnostics, ecology, epidemiology, and pathogenicity. *Vet Dermatol* 2012; 23: 253–266, e51-2.
8. Moodley A, Damborg P, Saxmose Nielsen S. Antimicrobial resistance in methicillin susceptible and methicillin resistant *Staphylococcus pseudintermedius* of canine origin: Literature review from 1980 to 2013. *Vet Microbiol* 2014; 171: 337–341.
9. Penna B, Varges R, Medeiros L, et al. Species distribution and antimicrobial susceptibility of staphylococci isolated from canine otitis external. *Vet Dermatol* 2009; 21: 292–296.
10. Morris DO, Loeffler A, Davis MF, et al. Recommendations for approaches to methicillin-resistant staphylococcal infections of small animals: diagnosis, therapeutic considerations and preventative measures: Clinical Consensus Guidelines of the World Association for Veterinary Dermatology. *Vet Dermatol* 2017; 28: 304-e69.
11. Kadlec K, Schwarz S. Antimicrobial resistance of *Staphylococcus pseudintermedius*. *Vet Dermatol* 2012; 23: 276–282, e55.
12. Pires Dos Santos T, Damborg P, Moodley A, et al. Systematic review on global epidemiology of methicillin-resistant *Staphylococcus pseudintermedius*: inference of population structure from multi locus sequence typing data. *Front Microbiol* 2016; 7: 1,599.
13. Frank LA, Loeffler A. Meticillin-resistant *Staphylococcus pseudintermedius*: clinical challenge and treatment options. *Vet Dermatol* 2012; 23: 283–291.
14. Futagawa-Saito K, Ba-Thein W, Fukuyasu T. High occurrence of multi-antimicrobial resistance in *Staphylococcus intermedius* isolates from healthy and diseased dogs and domesticated pigeons. *Res Vet Sci* 2007; 83: 336–339.

15. Onuma K, Tanabe T, Sato H. Antimicrobial resistance of *Staphylococcus pseudintermedius* isolates from healthy dogs and dogs affected with pyoderma in Japan. *Vet Dermatol* 2011; 23: 17–22, e5.
16. Kawakami T, Shibata S, Murayama N, et al. Antimicrobial susceptibility and methicillin resistance in *Staphylococcus pseudintermedius* and *Staphylococcus schleiferi* subsp. *coagulans* isolated from dogs with pyoderma in Japan. *J Vet Med Sci* 2010; 72: 1,615–1,619.
17. Murayama N, Nagata M, Terada Y, et al. *In vitro* antiseptic susceptibilities for *Staphylococcus pseudintermedius* isolated from canine superficial pyoderma in Japan. *Vet Dermatol* 2013; 24: 126–129.e29.
18. Bardiau M, Yamakazi K, Ote I, et al. Characterization of methicillin resistant *Staphylococcus pseudintermedius* isolated from dogs and cats. *Microbiol Immunol* 2013; 57: 496–501.
19. Kasai T, Saegusa S, Shirai M, et al. New categories designated as healthcare-associated and community-associated methicillin-resistant *Staphylococcus pseudintermedius* in dogs. *Microbiol Immunol* 2016; 60: 540–551.
20. van Duijkeren E, Catry B, Greko C, et al. Review on methicillin-resistant *Staphylococcus pseudintermedius*. *J Antimicrob Chemother* 2011; 66: 2,705–2,714.
21. Kurita G, Tsuyuki Y, Murata Y, et al. Reduced rates of antimicrobial resistance in *Staphylococcus intermedius* group and *Escherichia coli* isolated from diseased companion animals in an animal hospital after restriction of antimicrobial use. *J Infect Chemother* 2019; 25: 531–536.
22. CLSI. M39-A4: Analysis and Presentation of Cumulative Antimicrobial Susceptibility Test Data – 4th ed. Wayne, PA: Clinical and Laboratory Standards Institute; 2014.
23. Lamoth F, Wenger A, Prod'hom G, et al. Comparison of hospital-wide and unit-specific cumulative antibiograms in hospital- and community-acquired infection. *Infection* 2010; 38: 249–253.
24. Binkley S, Fishman NO, LaRosa LA, et al. Comparison of unit-specific and hospital-wide antibiograms: potential implications for selection of empirical antimicrobial therapy. *Infect Control Hosp Epidemiol* 2006; 27: 682–687.
25. Shimada E, Miyamoto T, Hatoya S. Causative bacteria and antibiogram in various infectious diseases in canines and felines. *J Jpn Vet Med Assoc* 2011; 64: 810–815.
26. Kagiyama N. Regulations and guidelines on scientific and ethical care and use of laboratory animals enforced on June 1, 2006. *J Intest Microbiol* 2007; 21: 1–8.
27. Japanese Ministry of Health, Labor and Welfare. Good Clinical Practice. Ministerial Ordinance No 28 and 24. Tokyo, Japan: Ministry of Health, Labor and Welfare; 1997 and 2008, respectively.
28. Sasaki T, Tsubakishita S, Tanaka Y, et al. Multiplex-PCR method for species identification of coagulase-positive staphylococci. *J Clin Microbiol* 2010; 48: 765–769.
29. CLSI. Performance standards for antimicrobial disk and dilution susceptibility tests for bacteria isolated from animals: approved standards – 5th ed. CLSI document VET01. Wayne, PA: Clinical and Laboratory Standards Institute; 2019.
30. CLSI. Performance standards for antimicrobial disk and dilution susceptibility tests for bacteria isolated from animals: approved standards – 4th ed. CLSI document VET08. Wayne, PA: Clinical and Laboratory Standards Institute; 2018.
31. CLSI. Performance standards for antimicrobial disk and dilution susceptibility tests for bacteria isolated from animals: approved standards – 30th ed. CLSI document M100.8. Wayne, PA: Clinical and Laboratory Standards Institute; 2020.
32. Westh H, Scheel Zinn C, Thamdrup Rosdahl V. An international multicenter study of antimicrobial consumption and resistance in *Staphylococcus aureus* isolates from 15 hospitals in 14 countries. *Microb Drug Resist* 2004; 10: 169–176.
33. McGowan JE Jr. Antimicrobial resistance in hospital organisms and its relation to antibiotic use. *Rev Infect Dis* 1983; 5: 1,033–1,048.
34. McGowan JE Jr. Is antimicrobial resistance in hospital microorganisms related to antibiotic use? *Bull N Y Acad Med* 1987; 63: 253–268.
35. Beco L, Guaguère E, Lorente Méndez C, et al. Suggested guidelines for using systemic antimicrobials in bacterial skin infections (1): diagnosis based on clinical presentation, cytology and culture. *Vet Rec* 2013; 172: 72–78.
36. Beco L, Guaguère E, Lorente Méndez C, et al. Suggested guidelines for using systemic antimicrobials in bacterial skin infections: part 2–antimicrobial choice, treatment regimens and compliance. *Vet Rec* 2013; 172: 156–160.
37. Hillier A, Lloyd DH, Weese JS, et al. Guidelines for the diagnosis and antimicrobial therapy of canine superficial bacterial folliculitis (Antimicrobial Guidelines Working Group of the International Society for Companion Animal Infectious Diseases). *Vet Dermatol* 2014; 25: 163-e43.
38. Yamazaki M, Kano R, Harada K, et al. Canine superficial pyoderma: an indication for antimicrobial and topical therapies. *Jpn J Vet Dermatol* 2017; 23: 127–134.
39. McCarthy AJ, Harrison EM, Stanczak-Mrozek K, et al. Genomic insights into the rapid emergence and evolution of MDR in *Staphylococcus pseudintermedius*. *J Antimicrob Chemother* 2015; 70: 997–1,007.
40. Borio S, Colombo S, La Rosa G, et al. Effectiveness of a combined (4% chlorhexidine digluconate shampoo and solution) protocol in MRS and non-MRS canine superficial pyoderma: a randomized, blinded, antibiotic-controlled study. *Vet Dermatol* 2015; 26: 339–344.

RÉSUMÉ

Contexte – La résistance antimicrobienne de *Staphylococcus pseudintermedius* (SP) et la prévalence des SP résistant à la méticiline (MRSP) est en augmentation chez les chiens à travers le monde.

Objectifs – Evaluer l'influence de la taille d'hôpital sur la résistance antimicrobienne de SP et si l'utilisation restreinte des antimicrobiens basée sur les antibiogrammes pourrait réduire l'identification des résistances antimicrobiennes des SP des chiens infectés.

Matériels et méthodes – Dans l'étude 1, un total de 2 294 Souches de SP de chiens avec pyodermite (n = 1,858, 52 hôpitaux) ou otite externe (OE; n = 436, 44 hôpitaux) pris entre 2017 et 2019 a été analysé. Les cliniques étaient catégorisées en petite, moyenne et large, selon le nombre de vétérinaires praticiens. Dans l'étude 2, un antibiogramme cumulatif a été construit pour 12 antimicrobiens d'une grande clinique vétérinaire de 2017 à 2018. Se référant à cet antibiogramme, la clinique a introduit des critères de sélection des antimicrobiens pour traiter les chiens avec pyodermite et OE, à partir de 2018.

Résultats – MRSP a été identifié chez 981 chiens (42,8%). Dans les grandes cliniques, le taux d'isolement des MRSP était de 51.1% (404 sur 791), qui était significativement plus élevé ($P < 0.01$) que dans les petites cliniques avec moins de deux vétérinaires (34.0%, 154 de 453). Dans l'étude antibiogramme, les taux de sensibilité de l'oxacilline (MPIPC, 61.5%), cefpodoxime (CPDX, 55.8%) et minocycline (MINO, 55.8%)

étaient significativement plus élevés en 2019 (n = 52) que 2017 à 2018 (n = 54; MPIPC, 37.0%; CPDX, 33.3%; MINO, 20.4%; $P < 0.05$).
Conclusions et importance clinique – La taille de l'hôpital pourrait affecter le taux d'isolement des MRSP chez les chiens. L'utilisation restreinte des antimicrobiens sur une année basée sur les antibiogrammes cumulatifs pourrait réduire les taux de résistance de multiples antimicrobiens des souches de SP des chiens avec pyodermite et OE.

RESUMEN
Introducción – la resistencia a los antimicrobianos en *Staphylococcus pseudintermedius* (SP) y la prevalencia de SP resistente a la meticilina (MRSP) está aumentando en perros en todo el mundo.
Objetivos – Evaluar la influencia del tamaño del hospital en la resistencia antimicrobiana de SP y si el uso restringido de antimicrobianos basado en antibiogramas podría reducir la identificación de resistencia antimicrobiana en SP de perros infectados.
Métodos y materiales – en el Estudio 1 se analizaron un total de 2294 aislamientos de SP de perros con pioderma (n = 1858, 52 hospitales) u otitis externa (OE; n = 436, 44 hospitales) obtenidos entre 2017 y 2019. Las clínicas se clasificaron en pequeñas, medianas y grandes según el número de veterinarios en ejercicio. En el Estudio 2, se construyó un antibiograma acumulativo para 12 antimicrobianos de una gran clínica veterinaria de 2017 a 2018. En referencia a este antibiograma, la clínica introdujo criterios estrictos de selección de antimicrobianos para tratar perros con pioderma y OE, a partir de 2018.
Resultados – se identificó MRSP en 981 perros (42,8%). En las clínicas grandes, la tasa de aislamiento de MRSP fue del 51,1% (404 de 791), que fue significativamente más alta (P <0,01) que en las clínicas pequeñas con menos de dos médicos veterinarios (34,0%, 154 de 453). En el estudio de antibiograma, las tasas de susceptibilidad de oxacilina (MPIPC, 61,5%), cefpodoxima (CPDX, 55,8%) y minociclina (MINO, 55,8%) fueron significativamente más altas en 2019 (n = 52) que en 2017 a 2018 (n = 54; MPIPC, 37,0%; CPDX, 33,3%; MINO, 20,4%; P<0,05).
Conclusiones y relevancia clínica – el tamaño del hospital podría afectar la tasa de aislamiento de MRSP en perros. El uso restringido de antimicrobianos durante más de un año basado en antibiogramas acumulativos podría reducir la tasa de resistencia de múltiples antimicrobianos en SP aislado de perros con pioderma y OE.

Zusammenfassung
Hintergrund – Die antimikrobielle Resistenz auf *Staphylococcus pseudintermedius* (SP) und die Prävalenz von Methicillin-resistenten SP (MRSP) nimmt bei den Hunden weltweit zu.
Ziele – Eine Evaluierung des Einflusses der Spitalsgröße auf die antimikrobielle Resistenz gegenüber SP und eine Feststellung, ob ein restriktiver Einsatz der Antibiotika basierend auf einem Antibiogramm die Identifizierung antimikrobieller Resistenzen auf SP bei infizierten Hunden reduzieren könnte.
Methoden und Materialien – In Studie 1 wurden insgesamt 2.294 SP Isolate von Hunden mit einer Pyodermie (n = 1.858; 52 Kliniken) oder Otitis externa (OE; n = 436; 44 Kliniken), die zwischen 2017 und 2019 genommen wurden, analysiert. Die Kliniken wurden anhand der praktizierenden Tierärzte in klein, medium und groß eingeteilt. In Studie 2 wurde ein kumulatives Antibiogramm für 12 Antibiotika aus einer großen Veterinärmedizinischen Klinik aus den Jahren 2017 bis 2018 konstruiert. Bezugnehmend auf dieses Antibiogramm führte die Klinik ab 2018 strikte antimikrobielle Selektionskriterien zur Behandlung von Hunden mit Pyodermie und OE ein.
Ergebnisse – Ein MRSP wurde bei 981 Hunden (42,8%) identifiziert. In großen Kliniken betrug die Isolationsrate für MRSP 51,1% (404 von 791), was signifikant höher war (P < 0,01) als in kleinen Kliniken mit weniger als zwei praktizierenden TierärztInnen (34,0%, 154 von 453). In der Antibiogramm Studie lagen die Empfindlichkeitswerte von Oxacillin (MPIPC; 61,5%), Cefpodoxim (CPDX; 55,8%) und Minocyclin (MINO; 55,8%) 2019 signifikant höher (n = 52) als 2017 bis 2018 (n = 54; MPIPC; 37,0%; CPDX; 33,3%; MINO; 20,4%; P < 0,05).
Schlussfolgerungen und klinische Bedeutung – Die Klinikgröße könnte die Isolationsrate von MRSP bei Hunden beeinflussen. Ein restriktiver Einsatz von Antibiotika für über ein Jahr basierend auf einem kumulativen Antibiogramm könnte die Resistenzrate von multiplen Antibiotika auf SP, welcher von Hunden mit Pyodermie und OE isoliert wird, reduzieren.

要約
背景 – Staphylococcus pseudintermedius（SP）の抗菌薬耐性およびメチシリン耐性SP（MRSP）の有病率は、世界中の犬で増加している。
目的 – 本研究の目的は、SPの抗菌薬耐性に対する病院規模の影響を評価し、アンチバイオグラムに基づく抗菌薬の使用制限が感染犬のSPにおける抗菌薬耐性の確認を低減できるかどうかを検討することであった。
材料と方法 – 研究1では、2017年から2019年の間に採取された、膿皮症（n＝1,858、52病院）または外耳

炎（OE；n＝436、44病院）の犬から分離された合計2,294個のSPを解析した。診療所は、開業している獣医外科医の数に基づいて、小、中、大規模に分類した。研究2では、2017年から2018年にかけて、1つの大規模な動物病院から12種類の抗菌薬について累積的なアンチバイオグラムを構築した。このアンチバイオグラムを参考に、同クリニックは2018年から膿皮症やOEの犬の治療に厳格な抗菌薬選択基準を導入した。

結果 – 981頭（42.8%）の犬でMRSPが確認された。大規模クリニックにおけるMRSPの分離率は51.1%（791頭中404頭）であり、獣医師が2名以下の小規模クリニック（34.0%、453頭中154頭）よりも有意に高かった（P＜0.01）。アンチバイオグラム調査では、オキサシリン（MPIPC、61.5%）、セフポドキシム（CPDX、55.8%）、ミノサイクリン（MINO、55.8%）の感受性率は、2017～2018年（n＝54、MPIPC、37.0%、CPDX、33.3%、MINO、20.4%、P＜0.05）に比べ、2019年（n＝52）は有意に高かった。

結論と臨床的関連性 – 病院の規模は、犬のMRSPの分離率に影響を与える可能性がある。累積アンチバイオグラムに基づいて1年以上抗菌薬の使用を制限することで、犬の膿皮症やOEから分離されたSPの複数の抗菌薬に対する耐性率を低下させることができた。

摘要

背景 — 假中间型葡萄球菌(SP)的抗菌药物耐药性和耐甲氧西林SP(MRSP)的流行率在全球犬中不断增加。

目的 — 评估医院规模对SP抗菌药物耐药性的影响，以及根据抗菌谱限制使用抗菌药，是否可减少感染犬SP抗菌药物耐药性。

方法和材料 — 在研究1中，对2017年至2019年间从脓皮病（n = 1,858，52家医院）或外耳炎（OE；n = 436，44家医院）犬中采集的总计2,294株SP分离株进行了分析。根据执业兽医的数量，将诊所分为小、中和大。在研究2中，从2017年至2018年，一家大型兽医诊所通过积累经验，构建了12种抗菌剂的抗菌谱。参考该抗菌谱，该诊所从2018年开始引入严格的抗菌药物选择标准来治疗脓皮病和OE犬。

结果 — 981只犬(42.8%)鉴定出MRSP。在大诊所中，MRSP的分离率为51.1%（791人中的404人），显著高于(P < 0.01)兽医从业人员少于2人的小诊所（34.0%，453人中的154人）。在抗菌谱研究中，2019年(n = 52)苯唑西林(MPIPC，61.5%)、头孢泊肟(CPDX，55.8%)和米诺环素(MINO，55.8%)的敏感率显著高于2017年至2018年(n = 54；MPIPC，37.0%；CPDX，33.3%；MINO，20.4%；P < 0.05)。

结论和临床相关性 — 医院规模可能影响犬MRSP的分离率。根据累积抗菌谱限制使用抗菌药一年以上，可降低脓皮病和OE犬分离SP对多种抗菌药的耐药率。

Resumo

Contexto – A resistência a antimicrobianos em *Staphylococcus pseudintermedius* (SP) e a prevalência de SP resistente à meticilina (MRSP) vem aumentando em cães em todo o mundo.

Objetivos – Avaliar a influência do tamanho do hospital na resistência antimicrobiana de SP e se o uso restrito de antimicrobianos com base em antibiogramas poderia reduzir a identificação de resistência a antimicrobianos em SP de cães infectados.

Métodos e materiais – No Estudo 1, um total de 2.294 isolados de SP de cães com piodermite (n = 1.858, 52 hospitais) ou otite externa (OE; n = 436, 44 hospitais) coletados entre 2017 e 2019 foram analisados. As clínicas foram categorizadas em pequenas, médias e grandes com base no número de cirurgiões veterinários em atividade. No Estudo 2, um antibiograma cumulativo foi elaborado para 12 antimicrobianos de uma grande clínica veterinária de 2017 a 2018. Referindo-se a este antibiograma, a clínica introduziu critérios de seleção de antimicrobianos estritos para tratar cães com piodermite e OE, a partir de 2018.

Resultados – A MRSP foi identificada em 981 cães (42,8%). Em grandes clínicas, a taxa de isolamento de MRSP foi de 51,1% (404 de 791), que foi significativamente maior (P <0,01) do que em pequenas clínicas com menos de dois médicos veterinários (34,0%, 154 de 453). No estudo de antibiograma, as taxas de suscetibilidade de oxacilina (MPIPC, 61,5%), cefpodoxima (CPDX, 55,8%) e minociclina (MINO, 55,8%) foram significativamente maiores em 2019 (n = 52) do que em 2017-2018 (n = 54; MPIPC, 37,0%; CPDX, 33,3%; MINO, 20,4%; P <0,05).

Conclusões e relevância clínica – O tamanho do hospital pode afetar a taxa de isolamento de MRSP em cães. O uso restrito de antimicrobianos por mais de um ano com base em antibiogramas cumulativos pode reduzir a taxa de resistência de vários antimicrobianos em SP isolados de cães com piodermite e OE.

