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Aerobic Antimicrobial Susceptibility Patterns of Bacteria Isolated from Dogs

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Abstract : Isolation and identification of causative microorganisms and susceptibility testing are important in selecting appropriate antimicrobial agent. The purpose of this study was to determine the antimicrobial susceptibility patterns and identification of bacteria for the selection of a therapeutic antibiotic agent for treatment. Specimens were cultured aerobically from dog patients brought to the veterinary medical teaching hospital of Seoul National University between July 1999 and September 2000. A total of 157 isolates were from skin(63), urine(45), ear canal(31) and conjunctiva(18). The result is that the most common organisms isolated from dog patients were *S. intermedius* was the most common isolates from the skin, ear canal, and conjunctiva. *E. coli* was the most common isolated from urine. Most of gram-positive isolates were resistant to ampicillin(80.6%), erythromycin(68.8%), penicillin(86.2%), tetracycline(89.2%). Otherwise most of gram-negative isolates were resistant to ampicillin(73.4%), trimethoprim-sulfa(53.3%). *E. coli* was resistant to ciprofloxacin(61.5%), piperacillin (69.2%). Antimicrobial susceptibility pattern by the sampling site was not remarkably different except *S. aureus* isolated from urine.

Key words : antimicrobial susceptibility, aerobic culture, dog

Introduction

Treatment of bacterial infections of animal mostly rely upon the use of antimicrobial agents. Therefore, isolation and identification of causative microorganisms and susceptibility testing are important in selecting appropriate antimicrobial agent1. But most animals in infectious processes are treated with antimicrobial agents prior to identifying the etiologic agent and susceptibility test result. Since the result of antimicrobial susceptibility to the infectious agent requires at least 48 hours[3], the initial selection of an antimicrobial agent is based on results of cytologic evaluation of stained specimens or accumulated information obtained from other animals with similar infections[5]. Selection of antimicrobial agent should be determined by experience with the infectious agent or condition, the location of infection, the status of patient and economic considerations. Experience includes knowledge of response to a particular therapy, or previously-obtained data on antimicrobial susceptibility to the isolates, or both. Application of antimicrobial susceptibility data in a retrospective fashion to remove the causative microorganism is helpful to veterinarian for successful management[10]. However there is limited information available on the antimicrobial susceptibility patterns of veterinary clinical specimens[4]. The primary purpose of this study was to determine the antimicrobial susceptibility patterns to be an useful data for the selection of a antibiotic agent for therapy in veterinary practices and to describe the recent trends in antimicrobial susceptibility to bacteria isolated from dog patients. The total of bacterial agents were cultured aerobically in this study.

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Materials and Methods

Bacterial specimens preperation

Specimens included in this study were obtained from dog patients brought to the Veterinary Medical Teaching Hospital of Seoul National University between July 1999 and September 2000 and they were cultured aerobically. Sampling sites were skin, urine, ear canal, and conjunctiva. Dermal specimens are obtained from swab samples taken from skin lesions of dogs with clinical signs of pyoderma. Urine specimens were obtained by antepubic cystocentesis from dogs with urinary tract infection (UTI). Cystocentesis constitutes the best way to collect urine for bacterial culture, because it prevents urine from being contaminated by bacteria inhabiting the distal urethra, prepuce, and vulva[6]. So specimens collected by catheterization, voiding or bladder expression were excluded. Ear specimens were obtained from the horizontal canal of each ear of otitis externa with sterile cotton-tipped swab. Conjunctival specimens were taken by carefully swabbing the conjunctiva with a sterile cotton-tipped swab moistened with saline in patients with conjunctivitis.

Bacterial culture and identification

Samples from each sites were incubated in Tryptic Soy Broth (TSB) for 24-48 hours at 37°C. And then cultured on 5% sheep blood agar (KOMED) and MacConkey agar (KOMED), and examined after overnight incubation at 37°C. Primary characteristics of colony in blood agar or MacConkey agar were recorded. Primary characteristics are pigmentation, hemolytic pattern, catalase reaction, coagulase reaction, oxidase reaction, Gram stain, and cellular morphology[2]. Iso-

lates were stored at -70°C in 15% glycerol broth. These samples are identified with GPI and GNI cards in VITEK system (bio Merieux Vitek, Hazelwood, MO, USA).

Antibiotic suseptibility testing

Antibiotic susceptibilities were tested with the VITEK system (bio Merieux Vitek, Hazelwood, MO, USA). Antimicrobial agents used for gram-positive bacteria were ampicillin, amoxacillin-clavulanate, ampicillin/sulbactam, cefazolin, ciprofloxacin, clindamycin, enrofloxacin, erythromycin, gentamicin, levofloxacin, nitrofurantoin, oxacillin, penicillin, rifampin, tetracycline, trimethoprim-sulfadiazine, and vancomycin. For Gram-negative bacteria amikacin, ampicillin, ampicillin/sulbactam, cefazolin, cefotaxime, cefotetan, ceftazidime, ceftriaxone, ciprofloxacin, gentamicin, imipenem, ofloxacin, piperacillin, ticarcillin/CA, tobramycin and trimethoprime-sulfadiazine were used. Susceptibilities for amoxicillin-clavulanate and enrofloxacin were tested by a broth dilution method[8].

Differentiation *S. intermedius* from *S. aureus*

Because VITEK system for the identification of bacteria does not reliably differentiate *S. intermedius* from *S. aureus*, additional tests were used to differentiate coagulase-positive isolates. Since all coagulase-positive staphylococci resistant to polymyxin B are *S. aureus*, isolates were tested for polymyxin B resistance by a disk diffusion test, using 300 unit disks and Muller-Hinton agar plates[9]. Isolates less than 8 mm in diameter of inhibitory zone were determined as resistant to polymyxin B; isolates more than 12 mm in diameter of inhibitory zone were determined as susceptible to polymyxin B. Mannitol salt agar was used to characterize aerobic fermentation of mannitol by the isolates; *S. aureus* metabolize mannitol readily, resulting in a yellow color change in the agar after 24 hours, whereas *S. intermedius* results in a delayed reaction (slight or no color change at 24 hours).

Table 1. Isolated bacteria by the sampling sites (%)

Microorganism	Skin	Urine	Ear Canal	Conjunctiva
S. aureus	12.7	8.9	9.7	11.1
	(8/63)	(4/45)	(3/31)	(2/18)
S. intermedius	55.6	4.4	29	38.9
	(35/63)	(2/45)	(9/31)	(7/18)
CNS	6.3	2.2	6.5	0.0
	(4/63)	(1/45)	(2/31)	(0/18)
Enterococcus faecium	0.0	4.4	6.5	5.6
	(0/63)	(2/45)	(2/31)	(1/18)
E. coli	1.6	40.0	16.1	11.1
	(1/63)	(18/45)	(5/31)	(2/18)
Klebsiella pneumoniae	3.2	13.3	0.0	0.0
	(2/63)	(6/45)	(0/31)	(0/18)
Proteus mirabilis	1.6	6.7	12.9	0.0
	(1/63)	(3/45)	(4/31)	(0/18)
Proteus vulgaris	0.0	2.2	0.0	0.0
	(0/63)	(1/45)	(0/31)	(0/18)
Pseudomonas aeruginosa	1.6	4.4	6.5	5.6
	(1/63)	(2/45)	(2/31)	(1/18)
Unidentified	17.5	13.3	12.9	27.8
	(11/63)	(6/45)	(4/31)	(5/18)

CNS : Coagulase-Negative Staphylococci
( ) : Number of isolates/Number of samples

Results

A total of 157 isolates were collected from skin, urine, ear canal and conjunctiva in dogs (Table 1). Number of isolates are 63 from skin, 45 from urine, 31 from ear canal and 18 from conjunctiva, respectively. Of these, 94 isolates were gram-positive, and 63 isolates were gram-negative bacteria.

Isolated bacteria by the sampling sites

The isolated bacteria by the sampling sites are shown in Table 2. Common organisms isolated from dog patients were *S. intermedius, E. coli,* and *S. aureus. S. intermedius* was the most common isolates from the skin, ear canal, and conjunctiva. *E. coli* was the most common isolates from urine.

Antimicrobial susceptibility of gram-positive and -negative bacterial isolates

The patterns of antimicrobial susceptibility of gram-posi-

Table 2. Patterns of antimicrobial susceptibility of G(+) bacterial isolates (%) (n=93)

Antibiotics	R	I	S
ampicillin(30 μg)	80.6	0.0	19.4
amoxacillin/clavulanate(10 μg)	9.2	0.0	90.8
ampicillin/sulbactam (10 μg/10 μg)	9.2	0.0	90.8
cefazolin(30 μg)	4.6	1.1	94.3
ciprofloxacin(5 μg)	12.9	10.1	86.0
clindamycin(2 μg)	23.0	0.0	77.0
enrofloxacin(10 μg)	15.1	0.0	85.0
erythromycin(15 μg)	68.8	18.2	13.0
gentamicin(10 μg)	35.6	13.8	50.6
levofloxacin(5 μg)	12.9	0.0	87.1
nitrofurantoin(300 μg)	11.8	1.1	87.1
oxacillin(1 μg)	6.9	0.0	93.1
penicillinG(10IU/IE/UI)	86.2	0.0	13.8
rifampin(5 μg)	18.4	27.6	54.0
tetracyclin(30 μg)	89.2	0.0	10.8
trimethoprim-sulfa (1.25 μg)	28.7	0.0	71.3
vancomycin(30 μg)	4.3	0.0	95.7

R : resistant, I : intermediate, S : susceptible

tive and -negative bacterial isolates are shown in Table 3 and Table 4. Most of gram-positive isolates were resistant to ampicillin, erythromycin, penicillin, and tetracycline. Otherwise most of gram-negative isolates were resistant to ampicillin and trimethoprim-sulfa.

Table 3. Patterns of antimicrobial susceptibility of G(-) bacterial isolates (%) (n=64)

Antibiotics	R	I	S
amikacin(30 μg)	3.1	0.0	96.9
ampicillin(10 μg)	73.4	0.0	26.6
ampicillin/sulbactam (10 μg/10 μg)	26.6	21.9	51.6
cefazolin(30 μg)	26.6	9.4	64.1
cefotaxime(30 μg)	0.0	3.1	96.9
cefotetan(30 μg)	3.1	6.3	90.6
ceftazidime(30 μg)	1.6	6.3	92.2
ceftriaxone(30 μg)	0.0	3.1	96.9
ciprofloxacin(5 μg)	29.7	6.3	64.1
gentamicin(10 μg)	40.6	1.6	57.8
imipenem(10 μg)	7.8	6.3	85.9
ofloxacin(5 μg)	32.8	4.7	62.5
piperacillin(100 μg)	37.5	3.1	59.4
ticarcillin/CA (100 μg/10 μg)	17.2	7.8	75.0
tobramycin(10 μg)	14.1	6.3	79.7
trimethoprim-sulfa (1.25 μg)	53.3	0.0	46.9

R : resistant, I : intermediate, S : susceptible

Antimicrobial susceptibilities of the bacterial isolates

The antimicrobial susceptibilities of various antibiotics against the isolated bacteria are shown in Table 5 and Table 6. Of the gram-positive isolates, *S. intermedius* and Coagulase-Negative Staphylococci (CNS) were highly resistant to ampicillin, erythromycin, penicillin, and tetracycline. *S. aureus* were resistant to ampicillin, penicillin, and tetracycline. And *Enterococcus faecium* was resistant to tetracycline. Of the gram-negative isolates, *E. coli* was resistant to ampicillin, ciprofloxacin, piperacillin, and trimethoprim-sulfa. *Klebsiella pneumoniae* was resistant to ampicillin and trimethoprim-sulfa. *Proteus* spp. were resistant to ampicillin. *Pseudomonas aeruginosa* was resistant to ampicillin, cefazolin, and trimethoprim-sulfa.

Antimicrobial susceptibilities of the isolates according to the sampling sites

The antimicrobial susceptibilities of the isolates by the sampling sites are shown in tables 7 to table 14.

S. intermedius isolated from skin showed resistant pattern (67-91%) to ampicillin, erythromycin, penicillin, and tetracycline. *S. aureus* and CNS isolated from skin showed resistance (63%) to ampicillin, penicillin(100%), and tetracycline

Table 4. Antimicrobial susceptibilities of the G(+) isolates *S. intermedius*, *S. aureus*, Coagulase-Negative Staphylococci, *Enterococcus faecium* to various antibiotics (%)

Antibiotics	SI (n=55)			SA (n=17)			CNS (n=5)			EF (n=5)		
	(R)	(I)	(S)	(R)	(I)	(S)	(R)	(I)	(S)	(R)	(I)	(S)
ampicillin(30 μg)	89.1	0.0	10.9	70.6	0.0	29.4	100.0	0.0	0.0	0.0	0.0	100.0
amoxacillin/clavulanate(10 μg)	3.6	0.0	96.4	11.8	5.9	82.4	20.0	0.0	80.0	0.0	0.0	100.0
ampicillin/sulbactam (10 μg/10 μg)	5.5	0.0	94.5	29.4	0.0	70.6	0.0	0.0	100.0	NT	NT	NT
cefazolin(30 μg)	0.0	0.0	100.0	23.5	0.0	76.5	0.0	20.0	80.0	NT	NT	NT
ciprofloxacin(5 μg)	12.7	0.0	87.3	17.6	0.0	82.4	0.0	0.0	100.0	0.0	20.0	80.0
clindamycin(2 μg)	12.7	0.0	87.3	35.3	0.0	64.7	20.0	0.0	80.0	NT	NT	NT
enrofloxacin(10 μg)	12.7	0.0	87.3	17.6	0.0	82.4	40.0	0.0	60.0	0.0	0.0	100.0
erythromycin(15 μg)	65.5	14.5	20.0	41.2	23.5	35.6	60.0	20.0	20.0	NT	NT	NT
gentamicin(10 μg)	38.2	18.2	43.6	29.4	5.9	64.7	40.0	20.0	40.0	NT	NT	NT
levofloxacin(5 μg)	12.7	0.0	87.3	29.4	0.0	70.6	0.0	0.0	100.0	0.0	0.0	100.0
nitrofurantoin(300 μg)	16.4	0.0	83.6	11.8	5.9	82.4	0.0	0.0	100.0	0.0	20.0	80.0
oxacillin(1 μg)	0.0	0.0	100.0	35.3	0.0	64.7	0.0	0.0	100.0	NT	NT	NT
penicillinG (10IU/IE/UI)	89.1	0.0	10.9	70.6	0.0	88.2	100.0	0.0	0.0	0.0	0.0	100.0
rifampin(5 μg)	25.5	27.3	47.3	5.9	23.5	70.6	20.0	20.0	60.0	NT	NT	NT
tetracyclin(30 μg)	69.1	27.3	3.6	64.7	11.8	23.5	60.0	20.0	20.0	80.0	0.0	20.0
trimethoprim-sulfa (1.25 μg)	34.5	0.0	65.5	17.6	0.0	82.4	0.0	0.0	100.0	NT	NT	NT
vancomycin(30 μg)	0.0	0.0	100.0	11.8	0.0	88.2	20.0	0.0	80.0	20.0	0.0	80.0

SI : *S. intermedius*, SA : *S. aureus*, CNS : Coagulase-Negative Staphylococci, EF : *Enterococcus faecium*, R : resistant, I : intermediate, S : susceptible, NT : Not Tested

Table 5. Antimicrobial susceptibilities of the G(-) isolates *E. coli*, *Klebsiella pneumoniae*, *Proteus mirabilis*, *Pseudomonas aeruginosa*to various antibiotics (%)

Antibiotics	ECO (n=26)			KPN (n=8)			PMI (n=9)			PSA (n=6)		
	(R)	(I)	(S)	(R)	(I)	(S)	(R)	(I)	(S)	(R)	(I)	(S)
amikacin(30 μg)	3.8	0.0	96.2	12.5	0.0	87.5	0.0	0.0	100.0	0.0	0.0	100.0
ampicillin(10 μg)	69.2	0.0	30.8	100.0	0.0	0.0	66.7	0.0	33.3	100.0	0.0	0.0
ampicillin/sulbactam (10 μg/10 μg)	30.8	38.5	30.8	37.5	25.0	37.5	0.0	22.2	77.8	33.3	0.0	66.7
cefazolin(30 μg)	15.4	23.1	61.5	37.5	0.0	62.5	44.4	0.0	55.6	100.0	0.0	0.0
cefotaxime(30 μg)	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	33.3	66.7
cefotetan(30 μg)	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	33.3	66.7	0.0
ceftazidime(30 μg)	0.0	11.5	88.5	12.5	12.5	75.0	0.0	0.0	100.0	0.0	0.0	100.0
ceftriaxone(30 μg)	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	33.3	66.7
ciprofloxacin(5 μg)	61.5	0.0	38.5	37.5	0.0	62.5	0.0	0.0	100.0	0.0	66.7	33.3
gentamicin(10 μg)	57.7	0.0	42.3	50.0	0.0	50.0	22.2	0.0	77.8	50.0	16.7	33.3
imipenem(10 μg)	7.7	0.0	92.3	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0
ofloxacin(5 μg)	57.7	0.0	42.3	37.5	0.0	62.5	0.0	0.0	100.0	50.0	50.0	0.0
piperacillin(100 μg)	69.2	0.0	30.8	37.5	12.5	50.0	0.0	0.0	100.0	16.7	16.7	66.7
ticarcillin/CA (100/10 μg)	23.1	15.4	61.5	37.5	12.5	50.0	0.0	0.0	100.0	33.3	0.0	66.7
tobramycin(10 μg)	11.5	7.7	80.8	37.5	0.0	62.5	0.0	0.0	100.0	16.7	33.3	50.0
trimethoprim-sulfa (1.25 μg)	61.5	0.0	38.5	87.5	0.0	12.5	11.1	0.0	88.9	100.0	0.0	0.0

ECO : *E. coli*, KPN : *Klebsiella pneumoniae*, PMI : *Proteus mirabilis*, PSA : *Pseudomonas aeruginosa*, R : resistant, I : intermediate, S : susceptible

Table 6. Antimicrobial susceptibility of the G(+) bacteria *S. intermedius*, *S. aureus*, Coagulase-Negative Staphylococci isolated from skin (%)

Antibiotics	SI (n=35)			SA (n=8)			CNS (n=4)		
	(R)	(I)	(S)	(R)	(I)	(S)	(R)	(I)	(S)
ampicillin(30 μg)	91.4	0.0	8.6	62.5	0.0	37.5	100.0	0.0	0.0
amoxacillin/clavulanate (10 μg)	2.9	0.0	97.1	12.5	0.0	87.5	25.0	0.0	75.0
ampicillin/sulbactam (10 μg/10 μg)	0.0	0.0	100.0	25.0	0.0	75.0	0.0	0.0	100.0
cefazolin(30 μg)	0.0	0.0	100.0	25.0	0.0	75.0	0.0	0.0	100.0
ciprofloxacin(5 μg)	17.1	0.0	82.9	12.5	0.0	87.5	0.0	0.0	100.0
clindamycin(2 μg)	17.1	0.0	82.9	25.0	0.0	75.0	0.0	0.0	100.0
enrofloxacin(10 μg)	11.4	0.0	88.6	12.0	0.0	87.5	25.0	0.0	75.0
erythromycin(15 μg)	71.4	14.3	14.3	37.5	25.0	37.5	50.0	25.0	25.0
gentamicin(10 μg)	42.9	20.0	37.1	12.5	12.5	75.0	25.0	25.0	50.0
levofloxacin(5 μg)	17.1	0.0	82.9	12.5	0.0	87.5	0.0	0.0	100.0
nitrofurantoin(300 μg)	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0
oxacillin(1 μg)	0.0	0.0	100.0	25.0	0.0	75.0	0.0	0.0	100.0
penicillinG(10IU/IE/UI μg)	91.4	0.0	8.6	62.5	0.0	37.5	100.0	0.0	0.0
rifampin(5 μg)	25.7	31.4	42.9	0.0	25.0	75.0	25.0	25.0	50.0
tetracyclin(30 μg)	68.6	28.6	2.9	62.5	0.0	37.5	75.0	25.0	0.0
trimethoprim-sulfa (1.25 μg)	40.0	0.0	60.0	0.0	0.0	100.0	0.0	0.0	100.0
vancomycin(30 μg)	0.0	0.0	100.0	12.5	0.0	87.5	25.0	0.0	75.0

SI : *S. intermedius*, SA : *S. aureus*, CNS : Coagulase-Negative Staphylococci, R : resistant, I : intermediate, S : susceptible

Table 7. Antimicrobial susceptibility of the G(-) bacteria *E. coli*, *Klebsiella pneumoniae*, *Proteus mirabilis*, *Pseudomonas aeruginosa* isolated from skin (%)

Antibiotics	ECO (n=1)			KPN (n=2)			PMI (n=1)			PSA(n=1)		
	(R)	(I)	(S)	(R)	(I)	(S)	(R)	(I)	(S)	(R)	(I)	(S)
amikacin (30 μg)	0.0	0.0	100.0	50.0	0.0	50.0	0.0	0.0	100.0	0.0	0.0	100.0
ampicillin (10 μg)	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0
ampicillin/ sulbactam (10 μg/10 μg)	100.0	0.0	0.0	50.0	50.0	0.0	0.0	0.0	100.0	0.0	0.0	100.0
cefazolin (30 μg)	0.0	100.0	0.0	50.0	0.0	50.0	100.0	0.0	0.0	100.0	0.0	0.0
cefotaxime (30 μg)	100.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0
cefotetan (30 μg)	100.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	100.0	0.0
ceftazidime (30 μg)	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0
ceftriaxone (30 μg)	100.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0
ciprofloxacin (5 μg)	100.0	0.0	0.0	50.0	0.0	50.0	0.0	0.0	100.0	0.0	100.0	0.0
gentamicin (10 μg)	100.0	0.0	0.0	50.0	0.0	50.0	0.0	0.0	100.0	0.0	0.0	100.0
imipenem (10 μg)	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0
ofloxacin (5 μg)	100.0	0.0	0.0	50.0	0.0	50.0	0.0	0.0	100.0	100.0	0.0	0.0
piperacillin (100 μg)	100.0	0.0	0.0	0.0	50.0	50.0	0.0	0.0	100.0	0.0	0.0	100.0
ticarcillin/CA (100 μg/10 μg)	100.0	0.0	0.0	50.0	0.0	50.0	0.0	0.0	100.0	0.0	0.0	100.0
tobramycin (10 μg)	0.0	0.0	100.0	50.0	0.0	50.0	0.0	0.0	100.0	0.0	0.0	100.0
trimethoprim-sulfa (1.25 μg)	100.0	0.0	0.0	50.0	0.0	50.0	0.0	0.0	100.0	100.0	0.0	0.0

ECO : *E. coli*, KPN : *Klebsiella pneumoniae*, PMI : *Proteus mirabilis*, PSA : *Pseudomonas aeruginosa*, R : resistant, I : intermediate, S : susceptible

(Table 6). One *E. coli* isolated from skin had resistance to antibiotics; ampicillin, ampicillin/sulbactam, cefotaxime, cefotetan, ceftriaxone, ciprofloxacin, gentamicin, ofloxacin, piperacillin, ticarcillin/CA, and trimethoprim-sulfa. *Klebsiella pneumoniae* showed resistance to ampicillin. *Proteus mirabilis* showed resistance to ampicillin and cefazolin. *Pseudomonas aeruginosa* showed resistance to ampicillin, cefazolin, ofloxacin and trimethoprim-sulfa (Table 7).

S. intermedius isolated from urine showed resistance to ampicillin, erythromycin, gentamicin, penicillin, rifampin and tetracycline. *S. aureus* showed resistance to antibiotics; ampicillin, ampicillin/sulbactam, cefazolin, clindamycin, erythromycin, gentamicin, levofloxacin, oxacillin, penicillin, and tetracycline. One CNS showed resistance to ampicillin, clindamycin, enrofloxacin, erythromycin, gentamicin, penicillin (Table 8). *E. coli* isolated from urine had resistance to antibiotics; ampicillin, ciprofloxacin, gentamicin, ofloxacin, piperacillin, and trimethoprim-sulfa. *Klebsiella pneumoniae* showed resistance to ampicillin and trimethoprim-sulfa. *Pseudomonas aeruginosa* showed resistance to ampicillin, cefazolin, and trimethoprim-sulfa (Table 9).

S. intermedius isolated from ear canal showed resistance to ampicillin and erythromycin. *S. aureus* and CNS showed resistance to ampicillin and penicillin. *Enterococcus faecium* showed resistance to rifampin (Table 10). *E. coli* isolated from ear canal had resistance to ampicillin, ciprofloxacin, piperacillin, and trimethoprim-sulfa. *Proteus mirabilis* showed resistance to ampicillin. *Pseudomonas aeruginosa* showed resistance to ampicillin, cefazolin, and trimethoprim-sulfa (Table 11).

S. intermedius isolated by conjunctival swab showed resistance to ampicillin, penicillin, and tetracycline. *Enterococcus faecium* showed resistance to tetracycline (Table 12). *Pseudomonas aeruginosa* showed resistance to ampicillin, cefazolin, ofloxacin and trimethoprim-sulfa (Table 13).

Antimicrobial susceptibility pattern by the sampling site was not remarkablely different except *S. aureus* isolated from urine.

Discussion

Choosing an appropriate break-point for interpretation of susceptibility was difficult. Due to the lack of universally agreed-upon guidelines for isolates obtained from animal sources, interpreted data was on the basis of NCCLS guidelines. One of the remarkable results in this study was the high resistance of isolates against ampicillin. It can be a reflex of the routine use of this drug and bacterial adaptation. But drugs combined with that can inhibit the role of beta-lactamase showed good activity. Therefore studies focused on the combined use of antibiotics or combination with agent that can elevate the activity of antibiotics would

Table 8. Antimicrobial susceptibility of the G(+) bacteria *S. intermedius*, *S. aureus*, Coagulase-Negative Staphylococci, *Enterococcus faecium* isolated from urine (%)

Antibiotics	SI (n=2)			SA (n=4)			CNS (n=1)			EF (n=2)		
	(R)	(I)	(S)	(R)	(I)	(S)	(R)	(I)	(S)	(R)	(I)	(S)
ampicillin (30 μg)	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	100.0
amoxacillin/clavulanate (10 μg)	0.0	0.0	100.0	25.0	25.0	50.0	0.0	0.0	100.0	0.0	0.0	100.0
ampicillin/sulbactam (10 μg/10 μg)	0.0	0.0	100.0	75.0	0.0	25.0	0.0	0.0	100.0	NT	NT	NT
cefazolin (30 μg)	0.0	0.0	100.0	75.0	0.0	25.0	0.0	100.0	0.0	NT	NT	NT
ciprofloxacin (5 μg)	0.0	0.0	100.0	50.0	0.0	50.0	0.0	0.0	100.0	0.0	50.0	50.0
clindamycin (2 μg)	0.0	0.0	100.0	75.0	0.0	25.0	100.0	0.0	0.0	NT	NT	NT
enrofloxacin (10 μg)	50.0	0.0	50.0	25.0	0.0	75.0	100.0	0.0	0.0	0.0	0.0	100.0
erythromycin (15 μg)	100.0	0.0	0.0	75.0	25.0	0.0	100.0	0.0	0.0	NT	NT	NT
gentamicin (10 μg)	100.0	0.0	0.0	75.0	0.0	25.0	100.0	0.0	0.0	NT	NT	NT
levofloxacin (5 μg)	0.0	0.0	100.0	75.0	0.0	25.0	0.0	0.0	100.0	0.0	0.0	100.0
nitrofurantoin (300 μg)	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	50.0	50.0
oxacillin (1 μg)	0.0	0.0	100.0	75.0	0.0	25.0	0.0	0.0	100.0	NT	NT	NT
penicillinG (10IU/IE/UI)	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	100.0
rifampin (5 μg)	100.0	0.0	0.0	0.0	25.0	75.0	0.0	0.0	100.0	NT	NT	NT
tetracyclin (30 μg)	100.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	100.0	50.0	0.0	50.0
trimethoprim-sulfa (1.25 μg)	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	NT	NT	NT
vancomycin (30 μg)	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	50.0	0.0	50.0

SI : *S. intermedius*, SA : *S. aureus*, CNS : Coagulase-Negative Staphylococci, EF : *Enterococcus faecium*, R : resistant, I : intermediate, S : susceptible, NT : Not Tested

Table 9. Antimicrobial susceptibility of the G(-) bacteria *E. coli*, *Klebsiella pneumoniae*, *Proteus mirabilis*, *Proteus vulgaris*, *Pseudomonas aeruginosa* isolated from urine (%)

Antibiotics	ECO (n=18)			KPN (n=6)			PMI (n=4)			PSA (n=2)		
	(R)	(I)	(S)	(R)	(I)	(S)	(R)	(I)	(S)	(R)	(I)	(S)
amikacin (30 μg)	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0
ampicillin (10 μg)	72.2	0.0	27.8	100.0	0.0	0.0	50.0	0.0	50.0	100.0	0.0	0.0
ampicillin/sulbactam (10 μg/10 μg)	33.3	38.9	27.8	33.3	16.7	50.0	0.0	0.0	100.0	50.0	0.0	50.0
cefazolin (30 μg)	22.2	22.2	55.6	33.3	0.0	66.7	25.0	0.0	75.0	100.0	0.0	0.0
cefotaxime (30 μg)	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	50.0	50.0
cefotetan (30 μg)	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	50.0	50.0	0.0
ceftazidime (30 μg)	0.0	11.1	88.9	16.7	16.7	66.7	0.0	0.0	100.0	0.0	0.0	100.0
ceftriaxone (30 μg)	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	50.0	50.0
ciprofloxacin (5 μg)	61.1	0.0	38.9	33.3	0.0	66.7	0.0	0.0	100.0	0.0	50.0	50.0
gentamicin (10 μg)	61.1	0.0	38.9	50.0	0.0	50.0	0.0	0.0	100.0	0.0	0.0	100.0
imipenem (10 μg)	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0
ofloxacin (5 μg)	61.1	0.0	38.9	33.3	0.0	66.7	0.0	0.0	100.0	50.0	50.0	0.0
piperacillin (100 μg)	72.2	0.0	27.8	50.0	0.0	50.0	0.0	0.0	100.0	0.0	0.0	100.0
ticarcillin/CA (100 μg/10 μg)	22.2	16.7	61.1	33.3	16.7	50.0	0.0	0.0	100.0	0.0	0.0	100.0
tobramycin (10 μg)	11.1	5.6	83.3	33.3	0.0	66.7	0.0	0.0	100.0	0.0	0.0	100.0
trimethoprim-sulfa (1.25 μg)	61.1	0.0	38.9	100.0	0.0	0.0	0.0	0.0	100.0	100.0	0.0	0.0

ECO : *E. coli*, KPN : *Klebsiella pneumoniae*, PMI : *Proteus mirabilis*, PSA : *Pseudomonas aeruginosa*, R : resistant, I : intermediate, S : susceptible

Table 10. Antimicrobial susceptibility of the bacteria *S. intermedius*, *S. aureus*, Coagulase-Negative Staphylococci, *Enterococcus faecium* isolated from ear canal (%)

Antibiotics	SI (n=9)			SA (n=3)			CNS (n=2)			EF (n=2)		
	(R)	(I)	(S)	(R)	(I)	(S)	(R)	(I)	(S)	(R)	(I)	(S)
ampicillin (30 μg)	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	100.0
amoxacillin/clavulanate (10 μg)	11.1	0.0	88.9	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0
ampicillin/sulbactam (10 μg/10 μg)	0.0	0.0	100.0	33.3	0.0	66.7	0.0	0.0	100.0	NT	NT	NT
cefazolin (30 μg)	0.0	0.0	100.0	33.3	0.0	67.7	0.0	0.0	100.0	NT	NT	NT
ciprofloxacin (5 μg)	11.1	0.0	72.7	33.3	0.0	66.7	0.0	0.0	100.0	0.0	0.0	100.0
clindamycin (2 μg)	11.1	0.0	72.7	33.3	0.0	66.7	0.0	0.0	100.0	NT	NT	NT
enrofloxacin (10 μg)	22.2	0.0	72.7	33.3	0.0	66.7	0.0	0.0	100.0	0.0	0.0	100.0
erythromycin (15 μg)	72.7	0.0	11.1	33.3	33.0	33.3	50.0	0.0	50.0	NT	NT	NT
gentamicin (10 μg)	33.3	33.3	33.3	33.3	0.0	66.7	50.0	0.0	50.0	0.0	0.0	100.0
levofloxacin (5 μg)	11.1	0.0	72.7	33.3	0.0	66.7	0.0	0.0	100.0	0.0	0.0	100.0
nitrofurantoin (300 μg)	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	NT	NT	NT
oxacillin (1 μg)	0.0	0.0	100.0	33.3	0.0	66.7	0.0	0.0	100.0	0.0	0.0	100.0
penicillinG (10IU/IE/UI)	0.0	0.0	100.0	100.0	0.0	0.0	100.0	0.0	0.0	NT	NT	NT
rifampin (5 μg)	22.2	11.1	66.7	33.3	33.3	33.3	50.0	0.0	50.0	100.0	0.0	0.0
tetracyclin (30 μg)	44.4	55.6	0.0	33.3	66.7	0.0	50.0	0.0	50.0	NT	NT	NT
trimethoprim-sulfa (1.25 μg)	55.6	0.0	44.4	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0
vancomycin (30 μg)	0.0	0.0	100.0	33.3	0.0	66.7	0.0	0.0	100.0	NT	NT	NT

SI : *S. intermedius*, SA : *S. aureus*, CNS : Coagulase-Negative Staphylococci, EF : *Enterococcus faecium*, R : resistant, I : intermediate, S : susceptible, NT : Not Tested

Table 11. Antimicrobial susceptibility of the bacteria *E. coli*, *Proteus mirabilis, Proteus vulgaris, Pseudomonas aeruginosa* isolated from ear canal (%)

Antibiotics	ECO (n=5)			PMI/PVU (n=4)			PSA (n=2)		
	(R)	(I)	(S)	(R)	(I)	(S)	(R)	(I)	(S)
amikacin (30 μg)	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0
ampicillin (10 μg)	60.0	0.0	40.0	75.0	0.0	25.0	100.0	0.0	0.0
ampicillin/sulbactam (10 μg/10 μg)	20.0	40.0	40.0	0.0	0.0	100.0	50.0	0.0	50.0
cefazolin (30 μg)	0.0	20.0	80.0	50.0	0.0	50.0	100.0	0.0	0.0
cefotaxime (30 μg)	0.0	0.0	100.0	0.0	0.0	100.0	0.0	50.0	50.0
cefotetan (30 μg)	0.0	0.0	100.0	0.0	0.0	100.0	50.0	50.0	0.0
ceftazidime (30 μg)	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0
ceftriaxone (30 μg)	0.0	0.0	100.0	0.0	0.0	100.0	0.0	50.0	50.0
ciprofloxacin (5 μg)	60.0	0.0	40.0	0.0	0.0	100.0	0.0	50.0	50.0
gentamicin (10 μg)	40.0	0.0	60.0	0.0	0.0	100.0	0.0	0.0	100.0
imipenem (10 μg)	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0
ofloxacin (5 μg)	40.0	0.0	60.0	0.0	0.0	100.0	0.0	100.0	0.0
piperacillin (100 μg)	60.0	0.0	40.0	0.0	0.0	100.0	0.0	0.0	100.0
ticarcillin/CA (100 μg/10 μg)	20.0	20.0	60.0	0.0	0.0	100.0	0.0	0.0	100.0
tobramycin (10 μg)	0.0	20.0	80.0	0.0	0.0	100.0	0.0	0.0	100.0
trimethoprim-sulfa (1.25 μg)	60.0	0.0	40.0	25.0	0.0	75.0	100.0	0.0	0.0

ECO : *E. coli*, KPN : *Klebsiella pneumoniae*, PMI : *Proteus mirabilis*, PSA : *Pseudomonas aeruginosa*, R : resistant, I : intermediate, S : susceptible

Table 12. Antimicrobial susceptibility of the bacteria *S. intermedius*, *S. aureus*, *Enterococcus faecium* isolated from conjunctiva (%)

Antibiotics	SI (n=7)			SA (n=2)			EF (n=1)		
	(R)	(I)	(S)	(R)	(I)	(S)	(R)	(I)	(S)
ampicillin (30 μg)	57.1	0.0	42.9	0.0	0.0	100.0	0.0	0.0	100.0
amoxacillin/clavulanate (10) μg	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0
ampicillin/sulbactam (10 μg/10 μg)	0.0	0.0	100.0	0.0	0.0	100.0	NT	NT	NT
cefazolin (30 μg)	0.0	0.0	100.0	0.0	0.0	100.0	NT	NT	NT
ciprofloxacin (5 μg)	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0
clindamycin (2 μg)	0.0	0.0	100.0	0.0	0.0	100.0	NT	NT	NT
enrofloxacin (10 μg)	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0
erythromycin (15 μg)	0.0	42.9	100.0	0.0	0.0	100.0	NT	NT	NT
gentamicin (10 μg)	0.0	0.0	100.0	0.0	0.0	100.0	NT	NT	NT
levofloxacin (5) μg	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0
nitrofurantoin (300) μg	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0
oxacillin (1) μg	0.0	0.0	100.0	0.0	0.0	100.0	NT	NT	NT
penicillinG (10IU/IE/UI)	57.1	0.0	42.9	0.0	0.0	100.0	0.0	0.0	100.0
rifampin (5 μg)	0.0	42.9	57.1	0.0	0.0	100.0	NT	NT	NT
tetracyclin (30 μg)	85.7	0.0	14.3	50.0	0.0	50.0	100.0	0.0	0.0
trimethoprim-sulfa (1.25 μg)	0.0	0.0	100.0	0.0	0.0	100.0	NT	NT	NT
vancomycin (30 μg)	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0

SI : *S. intermedius*, SA : *S. aureus*, EF : *Enterococcus faecium*, R : resistant, I : intermediate, S : susceptible, NT : Not Tested

Table 13. Antimicrobial susceptibility of the bacteria *E. coli*, *Pseudomonas aeruginosa* isolated from conjunctiva (%)

Antibiotics	ECO (n=2)			PSA (n=1)		
	(R)	(I)	(S)	(R)	(I)	(S)
amikacin (30 μg)	0.0	0.0	100.0	0.0	0.0	100.0
ampicillin (10 μg)	50.0	0.0	50.0	100.0	0.0	0.0
ampicillin/sulbactam (10 μg/10 μg)	0.0	50.0	50.0	0.0	0.0	100.0
cefazolin (30 μg)	0.0	0.0	100.0	100.0	0.0	0.0
cefotaxime (30 μg)	0.0	0.0	100.0	0.0	0.0	100.0
cefotetan (30 μg)	0.0	0.0	100.0	0.0	100.0	0.0
ceftazidime (30 μg)	0.0	0.0	100.0	0.0	0.0	100.0
ceftriaxone (30 μg)	0.0	0.0	100.0	0.0	0.0	100.0
ciprofloxacin (5 μg)	50.0	0.0	50.0	0.0	100.0	0.0
gentamicin (10 μg)	50.0	0.0	50.0	0.0	0.0	100.0
imipenem (10 μg)	0.0	0.0	100.0	0.0	0.0	100.0
ofloxacin (5 μg)	50.0	0.0	50.0	100.0	0.0	0.0
piperacillin (100 μg)	50.0	0.0	50.0	0.0	0.0	100.0
ticarcillin/CA (100 μg/10 μg)	0.0	0.0	100.0	0.0	0.0	100.0
tobramycin (10 μg)	50.0	0.0	50.0	0.0	0.0	100.0
trimethoprim-sulfa (1.25 μg)	50.0	0.0	50.0	100.0	0.0	0.0

ECO : *E. coli*, PSA : *Pseudomonas aeruginosa*, R : resistant, I : intermediate, S : susceptible

be more useful than the development of new antibiotics, and thought to be studied in these respects.

Comparison of data between clinical laboratories and on a yearly basis are considered to be important. And it will also be a useful data to study the response to the therapy in vivo[7].

The pattern of antimicrobial susceptibility from dogs was

determined. Most gram-positive isolates showed resistant pattern to ampicillin, erythromycin, penicillin and tetracycline. Most gram-negative isolates showed resistant pattern to ampicillin and trimethoprim-sulfa. *E. coli* had also resistance to ciprofloxacin and piperacillin. Difference in pattern by site of sampling was not remarkable except *S. aureus* obtained from urine.

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개에서 분리된 호기성 병원성 세균의 항생제 감수성

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요 약 : 질병을 유발하는 세균의 분리와 동정, 그리고 그 세균에 대한 항생제 감수성 검사는 치료에 효과적인 항생제를 선택하는 데에 있어서 중요하다. 본 연구의 목적은 항생제 감수성의 경향을 알아보고 치료를 위한 효과적인 항생제 선택을 위해 세균을 동정하는 것이었다. 1999년 7월부터 2000년 9월 사이에 서울대학교 수의과대학 부속동물병원에 내원한 개로부터 실험재료를 채취하여 호기배양을 실시하였다. 피부(63개), 뇨(45개), 외이도(31개), 안결막(18개) 으로부터 채취한 총 157개 시료를 이용하였다. 내원한 환자의 피부, 외이도, 결막에서 가장 많이 분리된 세균은 *S. intermedius*였다. 내원한 환자의 뇨에서 가장 많이 분리된 세균은 E. coli 였다. 분리된 그람 양성 세균의 대부분은 ampicillin(80.6%), erythromycin(68.8%), penicillin(86.2%), tetracycline(89.2%) 에 대해 저항성을 나타내었다. 반면, 분리된 그람 음성 세균의 대부분은 ampicillin(73.4%), trimethoprim-sulfa(53.3%) 에 대해 저항성을 나타내었다. *E. coli*는 ciprofloxacin(61.5%), piperacillin(69.2%) 에 대해 저항성을 나타내었다. 분리 동정된 세균의 채취 부위에 따른 항생제 감수성의 차이는 뇨중의 S. aureus를 제외하고는 특이할 만한 사항이 없었다.

주요어 : 항생제 감수성, 호기배양, 개