Original Article
Clinical Microbiology

Ann Lab Med 2015;35:479-486
http://dx.doi.org/10.3343/alm.2015.35.5.479
ISSN 2234-3806 • eISSN 2234-3814

ANNALS OF LABORATORY MEDICINE

Multicenter Study of Antimicrobial Susceptibility of Anaerobic Bacteria in Korea in 2012

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Background: Periodic monitoring of regional or institutional resistance trends of clinically important anaerobic bacteria is recommended, because the resistance of anaerobic pathogens to antimicrobial drugs and inappropriate therapy are associated with poor clinical outcomes. There has been no multicenter study of clinical anaerobic isolates in Korea. We aimed to determine the antimicrobial resistance patterns of clinically important anaerobes at multiple centers in Korea.

Methods: A total of 268 non-duplicated clinical isolates of anaerobic bacteria were collected from four large medical centers in Korea in 2012. Antimicrobial susceptibility was tested by the agar dilution method according to the CLSI guidelines. The following antimicrobials were tested: piperacillin, piperacillin-tazobactam, cefoxitin, cefotetan, imipenem, meropenem, clindamycin, moxifloxacin, chloramphenicol, metronidazole, and tigecycline.

Results: Organisms of the *Bacteroides fragilis* group were highly susceptible to piperacillin-tazobactam, imipenem, and meropenem, as their resistance rates to these three antimicrobials were lower than 6%. For *B. fragilis* group isolates and anaerobic gram-positive cocci, the resistance rates to moxifloxacin were 12-25% and 11-13%, respectively. Among *B. fragilis* group organisms, the resistance rates to tigecycline were 16-17%. Two isolates of *Finegoldia magna* were non-susceptible to chloramphenicol (minimum inhibitory concentrations of 16-32 mg/L). Resistance patterns were different among the different hospitals.

Conclusions: Piperacillin-tazobactam, cefoxitin, and carbapemems are highly active β-lactam agents against most of the anaerobes. The resistance rates to moxifloxacin and tigecycline are slightly higher than those in the previous study.

Key Words: Anaerobe, Multicenter, Imipenem, Moxifloxacin, Tigecycline

Received: January 6, 2015
Revision received: January 28, 2015
Accepted: May 11, 2015

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INTRODUCTION

Antimicrobial susceptibility testing (AST) may not be necessary for most clinical anaerobic strains isolated from routine anaerobic culture. The CLSI suggests testing of isolates from serious infections such as bacteremia, brain abscess, endocarditis, osteomyelitis, and joint infection [1]. Additionally, any bacteria isolated from normally sterile body sites or associated with a failure to respond to empirical treatment should be tested [1]. Antimicrobials that are potentially effective against anaerobic bacteria include β-lactams, combinations of β-lactams and β-lactamase inhibitors, metronidazole, chloramphenicol, clindamycin, mac-

rolides, tetracyclines, and fluoroquinolones [2].

Some anaerobic bacteria have become resistant to antimicrobial agents, and some can develop resistance while a patient is receiving therapy [3]. Moreover, there are reports that the resistance of anaerobic pathogens to antimicrobials and inappropriate therapy are associated with poor clinical outcomes [4, 5]. These findings emphasize the importance of performing susceptibility testing of organisms recovered from certain selected cases to guide therapeutic choices. In addition, regional susceptibility patterns play a pivotal role in the empirical treatment of infections caused by anaerobic bacteria.

In Korea, the AST for anaerobe has been regularly performed at Yonsei University Hospital [6, 7, 13], but there has been no multicenter study of clinical anaerobic isolates. We aimed to determine and compare the antimicrobial resistance patterns for clinically important anaerobes collected from four medical centers in Korea.

METHODS

1. Bacterial isolates

A total of 396 anaerobic isolates were prospectively collected at four tertiary-care hospitals (the Catholic University of Korea, CU; University of Ulsan College of Medicine, UU; Yonsei University College of Medicine, YU; Yonsei University Wonju College of Medicine, YW) from June to December 2012 and transported to YU for anaerobic identification and AST, as previously reported [7]. During this period, the isolates were consecutively collected at each hospital and recovered as one isolate per patient. Anaerobes were isolated from blood, body fluid, and abscess specimens. Each isolate was identified by conventional methods [8], the ATB 32A system (bioMérieux, Marcy l'Etoile, France), or the VITEK MS (bioMérieux) matrix-assisted laser desorption ionization–time-of-flight mass spectrometry system. *Propionibacterium acnes* was excluded from the data analysis and AST. A total of 268 randomly selected isolates were used for AST: 83 *Bacteroides fragilis*, 64 other *B. fragilis* group species, 16 *Prevotella* spp., 6 *Fusobacterium* spp., 12 *Veillonella* spp., 15 *Finegoldia magna*, 19 other gram-positive cocci, 26 *Clostridium* spp., and 27 other gram-positive bacilli.

2. Antimicrobial susceptibility testing

AST was performed by using the CLSI agar dilution method [1]. The medium used was Brucella agar (Becton Dickinson, Cockeysville, MD, USA) supplemented with 5 mg/L hemin, 1 mg/L vitamin K1, and 5% laked sheep blood. The antimicrobial powders used were piperacillin and tazobactam (Yuhan, Seoul, Korea), cefoxitin (Merck Sharp & Dohme, West Point, PA, USA), cefotetan (Daiichi Pharmaceutical, Tokyo, Japan), clindamycin (Korea Upjohn, Seoul, Korea), imipenem and metronidazole (Choong Wae, Seoul, Korea), chloramphenicol (Chong Kun Dang, Seoul, Korea), meropenem (Sumitomo, Tokyo, Japan), moxifloxacin (Bayer Korea, Seoul, Korea), and tigecycline (Wyeth Research, Pearl River, NY, USA). For the piperacillin-tazobactam combination, a constant concentration of 4 mg/L tazobactam was used. The tigecycline breakpoints of ≤ 4 and ≥ 16 mg/L, suggested by the US Food and Drug Administration, were used in this study [9].

An inoculum of 10^5 colony forming units (CFU) was applied with a Steers replicator (Craft Machine Inc., Woodline, PA, USA), and the plates were incubated in an anaerobic chamber (Forma Scientific, Marietta, OH, USA) for 48 hr at 37°C. The minimum inhibitory concentration (MIC) of the antimicrobial agent was defined as the concentration at which there was a marked reduction in growth, such as from confluent colonies to a haze, <10 tiny colonies, or several normal-sized colonies [1]. *B. fragilis* ATCC 25285 and *Bacteroides thetaiotaomicron* ATCC 29741 were used as the controls.

3. Carbapenemase screening test and detection of the *cfiA* gene

Imipenem and EDTA-sodium mercaptoacetic acid double-disk synergy (IEDDS) tests were carried out on Brucella agar to screen for carbapenemase-producing *B. fragilis* isolates [9]. The *cfiA* gene and its upstream insertion sequence (IS) were detected by PCR as previously described [10].

RESULTS

Table 1 shows the MICs of the antimicrobial agents and the resistance rates of the anaerobes tested. The resistance rates of *B. fragilis* isolates and other *B. fragilis* group organisms to piperacillin were 48-58%, whereas their resistance rates to piperacillin-tazobactam were 2-5%. Cefoxitin remained very active against *B. fragilis*, with only 4% of the isolates exhibiting resistance; however, 13% of other *B. fragilis* group isolates were resistant to this drug. Other *B. fragilis* group isolates were much more resistant to cefotetan, showing a 64% resistance rate. *B. fragilis* group isolates showed resistance rates of only 0-6% to the carbapenems, which are the most active β-lactam drugs. On the other hand, *B. fragilis* group isolates had high resistance rates of 52-80% to clindamycin. The resistance rates of the *B.*

http://dx.doi.org/10.3343/alm.2015.35.5.479

Table 1. Activity of antimicrobials against 268 anaerobic bacteria isolated from four hospitals in Korea from June to December 2012

Organism (N of isolates) and antimicrobial agent	Breakpoint (μg/mL)			MIC (μg/mL)			Susceptibility (%)		
	S	I	R	Range	50%	90%	S	I	R
Bacteroides fragilis (83)									
Piperacillin	≤32	64	≥128	2->256	64	>256	48	4	48
Piperacillin-tazobactam	≤32	64	≥128	≤0.06->128	0.5	8	96	1	2
Cefoxitin	≤16	32	≥64	4-128	8	32	83	13	4
Cefotetan	≤16	32	≥64	4->128	8	64	72	7	20
Imipenem	≤4	8	≥16	0.06-16	0.125	1	96	0	4
Meropenem	≤4	8	≥16	0.12-64	0.25	4	94	0	6
Clindamycin	≤2	4	≥8	≤0.06->128	>128	>128	47	1	52
Moxifloxacin	≤2	4	≥8	0.25-32	0.5	8	86	2	12
Chloramphenicol	≤8	16	≥32	2-8	4	4	100	0	0
Metronidazole	≤8	16	≥32	0.125-4	1	2	100	0	0
Tigecycline*	≤4	8	≥16	0.5-32	4	16	65	18	17
B. fragilis group, other (64)†									
Piperacillin	≤32	64	≥128	2->256	256	>256	38	5	58
Piperacillin-tazobactam	≤32	64	≥128	≤0.06->128	8	32	88	8	5
Cefoxitin	≤16	32	≥64	≤1-128	16	64	50	38	13
Cefotetan	≤16	32	≥64	2->128	64	>128	19	17	64
Imipenem	≤4	8	≥16	≤0.03-32	0.5	2	97	0	3
Meropenem	≤4	8	≥16	≤0.03-8	0.25	2	98	2	0
Clindamycin	≤2	4	≥8	≤0.06->128	>128	>128	13	8	80
Moxifloxacin	≤2	4	≥8	0.25-64	2	32	70	5	25
Chloramphenicol	≤8	16	≥32	2-16	4	8	98	2	0
Metronidazole	≤8	16	≥32	≤0.125-8	2	4	100	0	0
Tigecycline	≤4	8	≥16	≤0.06-32	4	16	63	22	16
Prevotella spp. (16)‡									
Piperacillin	≤32	64	≥128	≤1-64	16	32	94	6	0
Piperacillin-tazobactam	≤32	64	≥128	≤0.06	≤0.06	≤0.06	100	0	0
Cefoxitin	≤16	32	≥64	≤1-8	≤1	4	100	0	0
Cefotetan	≤16	32	≥64	≤1-16	4	16	100	0	0
Imipenem	≤4	8	≥16	≤0.03-0.06	0.06	0.06	100	0	0
Meropenem	≤4	8	≥16	≤0.03-0.125	0.125	0.125	100	0	0
Clindamycin	≤2	4	≥8	≤0.06->128	≤0.06	>128	63	0	38
Moxifloxacin	≤2	4	≥8	≤0.06-64	2	32	56	0	44
Chloramphenicol	≤8	16	≥32	≤0.5-8	2	8	100	0	0
Metronidazole	≤8	16	≥32	0.25-16	1	16	81	19	0
Tigecycline	≤4	8	≥16	0.125-4	0.25	2	100	0	0
Fusobacterium spp. (6)§									
Piperacillin	≤32	64	≥128	≤1-2	NA	NA	NA	NA	NA

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Table 1. Continued

Organism (N of isolates) and antimicrobial agent	Breakpoint (μg/mL)			MIC (μg/mL)			Susceptibility (%)		
	S	I	R	Range	50%	90%	S	I	R
Piperacillin-tazobactam	≤32	64	≥128	≤0.06-1	NA	NA	NA	NA	NA
Cefoxitin	≤16	32	≥64	≤1-2	NA	NA	NA	NA	NA
Cefotetan	≤16	32	≥64	≤0.1	NA	NA	NA	NA	NA
Imipenem	≤4	8	≥16	≤0.03-0.5	NA	NA	NA	NA	NA
Meropenem	≤4	8	≥16	≤0.03	NA	NA	NA	NA	NA
Clindamycin	≤2	4	≥8	≤0.06-8	NA	NA	NA	NA	NA
Moxifloxacin	≤2	4	≥8	0.125-4	NA	NA	NA	NA	NA
Chloramphenicol	≤8	16	≥32	≤0.5-2	NA	NA	NA	NA	NA
Metronidazole	≤8	16	≥32	≤0.125-0.25	NA	NA	NA	NA	NA
Tigecycline	≤4	8	≥16	≤0.06-0.25	NA	NA	NA	NA	NA
Veillonella spp. (12)[‖]									
Piperacillin	≤32	64	≥128	≤1-256	32	32	92	0	8
Piperacillin-tazobactam	≤32	64	≥128	≤0.06->128	8	16	92	0	8
Cefoxitin	≤16	32	≥64	≤1-8	≤1	4	100	0	0
Cefotetan	≤16	32	≥64	≤1	≤1	≤1	100	0	0
Imipenem	≤4	8	≥16	≤0.03-0.5	0.25	0.5	100	0	0
Meropenem	≤4	8	≥16	≤0.03	≤0.03	≤0.03	100	0	0
Clindamycin	≤2	4	≥8	≤0.06-0.125	≤0.06	0.125	100	0	0
Moxifloxacin	≤2	4	≥8	≤0.06-16	0.25	4	83	8	8
Chloramphenicol	≤8	16	≥32	1-2	1	2	100	0	0
Metronidazole	≤8	16	≥32	≤0.125-16	2	4	92	8	0
Tigecycline	≤4	8	≥16	0.25-2	1	1	100	0	0
Finegoldia magna (15)									
Piperacillin	≤32	64	≥128	≤1	≤1	≤1	100	0	0
Piperacillin-tazobactam	≤32	64	≥128	≤0.06-0.5	≤0.06	0.125	100	0	0
Cefoxitin	≤16	32	≥64	≤1-0.5	≤1	≤1	100	0	0
Cefotetan	≤16	32	≥64	≤1-4	≤1	2	100	0	0
Imipenem	≤4	8	≥16	≤0.03-0.125	≤0.03	0.06	100	0	0
Meropenem	≤4	8	≥16	≤0.03-0.125	0.06	0.125	100	0	0
Clindamycin	≤2	4	≥8	≤0.06->128	4	>128	47	13	40
Moxifloxacin	≤2	4	≥8	≤0.06-32	0.125	16	87	0	13
Chloramphenicol	≤8	16	≥32	2-32	4	16	87	7	7
Metronidazole	≤8	16	≥32	0.25-2	0.5	1	100	0	0
Tigecycline	≤4	8	≥16	0.125-0.5	NA	NA	100	0	0
Other gram-positive cocci (19)[¶]									
Piperacillin	≤32	64	≥128	≤1-16	≤1	8	100	0	0
Piperacillin-tazobactam	≤32	64	≥128	≤0.06-16	≤0.06	8	100	0	0
Cefoxitin	≤16	32	≥64	≤1-16	≤1	16	100	0	0

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http://dx.doi.org/10.3343/alm.2015.35.5.479

Table 1. Continued

Organism (N of isolates) and antimicrobial agent	Breakpoint (μg/mL)			MIC (μg/mL)			Susceptibility (%)		
	S	I	R	Range	50%	90%	S	I	R
Cefotetan	≤16	32	≥64	≤1-128	≤1	64	84	0	16
Imipenem	≤4	8	≥16	≤0.03-2	≤0.03	1	100	0	0
Meropenem	≤4	8	≥16	≤0.03-4	≤0.03	4	100	0	0
Clindamycin	≤2	4	≥8	≤0.06-32	≤0.06	4	89	5	5
Moxifloxacin	≤2	4	≥8	≤0.06-8	0.25	8	89	0	11
Chloramphenicol	≤8	16	≥32	≤0.5-4	2	4	100	0	0
Metronidazole	≤8	16	≥32	≤0.125->32	0.5	>32	89	0	11
Tigecycline	≤4	8	≥16	≤0.06-0.5	0.125	0.25	100	0	0
Clostridium spp. (26)**									
Piperacillin	≤32	64	≥128	≤1-32	≤1	16	100	0	0
Piperacillin-tazobactam	≤32	64	≥128	≤0.06-32	≤0.06	32	100	0	0
Cefoxitin	≤16	32	≥64	≤1-32	≤1	32	88	12	0
Cefotetan	≤16	32	≥64	≤1->128	≤1	4	96	0	4
Imipenem	≤4	8	≥16	≤0.03-8	0.125	1	96	4	0
Meropenem	≤4	8	≥16	≤0.03-8	≤0.03	1	96	4	0
Clindamycin	≤2	4	≥8	≤0.06->128	2	>128	65	12	23
Moxifloxacin	≤2	4	≥8	≤0.06-32	0.5	8	85	4	12
Chloramphenicol	≤8	16	≥32	≤0.5-8	2	4	100	0	0
Metronidazole	≤8	16	≥32	≤0.125-4	1	2	100	0	0
Tigecycline	≤4	8	≥16	≤0.06-4	0.25	4	100	0	0
Other gram-positive bacilli (27)††									
Piperacillin	≤32	64	≥128	≤1-32	≤1	16	100	0	0
Piperacillin-tazobactam	≤32	64	≥128	≤0.06-32	1	16	100	0	0
Cefoxitin	≤16	32	≥64	≤1-16	8	16	100	0	0
Cefotetan	≤16	32	≥64	≤1-128	16	64	59	7	33
Imipenem	≤4	8	≥16	≤0.03-0.5	0.125	0.5	100	0	0
Meropenem	≤4	8	≥16	≤0.03-0.5	0.25	0.5	100	0	0
Clindamycin	≤2	4	≥8	≤0.06->128	≤0.06	128	85	0	15
Moxifloxacin	≤2	4	≥8	≤0.06-64	1	4	89	7	4
Chloramphenicol	≤8	16	≥32	≤0.5-8	2	4	100	0	0
Metronidazole	≤8	16	≥32	0.25->32	1	>32	70	4	26
Tigecycline	≤4	8	≥16	≤0.06-0.5	0.25	0.5	100	0	0

*US Food and Drug Administration breakpoints were used for tigecycline; †*Bacteroides thetaiotaomicron* (n=25), *B. ovatus* (n=8), *B. vulgatus* (n=8), *Parabacteroides distasonis* (n=8), *B. uniformis* (n=4), *B. salyersae* (n=3), *B. caccae* (n=2), *B. dorei* (n=1), *B. nordii* (n=1), *B. stercoris* (n=1), *Odoribacter splanchnicus* (n=1), *Bacteroides* sp. (n=2); ‡*Prevotella bivia* (n=4), *P. buccae* (n=3), *P. intermedia* (n=3), *P. denticola* (n=1), *P. disiens* (n=1), *P. melaninogenica* (n=1), *P. oralis* (n=1); §*Fusobacterium necrophorum* (n=2), *F. nucleatum* (n=2), *F. varium* (n=1), *Fusobacterium* sp. (n=1); ‖*Veillonella parvula* (n=10), *Veillonella* sp. (n=2); ¶*Parvimonas micra* (n=7), *Peptostreptococcus anaerobius* (n=4), *Peptoniphilus asaccharolyticus* (n=3), *Peptostreptococcus* sp. (n=3), *Streptococcus asaccharolyticus* (n=2); **Clostridium perfringens* (n=11), *C. ramosum* (n=2), *C. tertium* (n=2), *C. baratii* (n=1), *C. clostridioforme* (n=1), *C. paraputrificum* (n=1), *Clostridium* sp. (n=8); ††*Actinomyces meyeri* (n=2), *Actinomyces naeslundii* (n=1), *Actinomyces neuii* (n=1), *Actinomyces* sp. (n=5), *Bifidobacterium* sp. (n=1); *Collinsella aerofaciens* (n=3), *Eggerthella lenta* (n=10), *Eubacterium lentum* (n=3), *Eubacterium* sp. (n=1).
Abbreviations: S, susceptible; I, intermediate; R, resistant; NA, not available/not applicable.

fragilis group organisms to moxifloxacin and tigecycline were 12-25% and 16-17%, respectively. All *B. fragilis* group isolates were susceptible to chloramphenicol and metronidazole.

Prevotella isolates were susceptible to all antimicrobial agents tested, except for clindamycin (38% resistant) and moxifloxacin (44% resistant). The resistance rate to clindamycin was 40% for *F. magna* and 5% for other gram-positive cocci. It should be noted that two isolates of *F. magna* showed non-susceptibility to chloramphenicol, with MICs of 16-32 mg/L. *Clostridium* isolates, including *C. perfringens*, were generally susceptible to the test drugs, except for clindamycin (23% resistant) and moxifloxacin (12% resistant). Other gram-positive bacilli such as *Actinomyces*, *Bifidobacterium*, *Eggerthella*, and *Collinsella* species were generally susceptible to the β-lactams, including piperacillin, but were resistant to cefoxitin (33%), metronidazole (26%), clindamycin (15%), and moxifloxacin (4%).

Table 2 shows the resistance rates of the *B. fragilis* group and other *B. fragilis* group isolates in each hospital and reveals some differences in resistance patterns among the hospitals. High resistance rates to cefotetan (33%) at YW and to moxifloxacin (22%) at CU were noted for *B. fragilis* isolates. Among non-*B. fragilis* isolates, the highest resistance rates were observed toward piperacillin-tazobactam (13%) at YU and toward moxifloxacin (57%) at CU.

Two imipenem-resistant *B. fragilis* isolates showed positive results on the IEDDS test, whereas two imipenem-resistant *B. thetaiotaomicron* isolates did not. The *cfiA* gene and its upstream IS elements were detected in two imipenem-resistant *B. fragilis* isolates.

Table 2. Comparison of resistance rates of *Bacteroides fragilis* and other *Bacteroides* spp. isolates by hospital

Antimicrobial agent	Resistance rates (%) of *B. fragilis*/resistance rates (%) of other *B. fragilis* group isolates			
	CU (23/14)*	YU (22/24)	UU (17/16)	YW (21/10)
Piperacillin	52/57	23/79	53/50	67/20
Piperacillin-tazobactam	0/0	0/13	6/0	0/0
Cefoxitin	0/0	5/17	12/25	0/0
Cefotetan	22/57	9/75	18/63	33/50
Imipenem	0/0	0/8	18/0	0/0
Meropenem	4/0	5/0	18/0	0/0
Clindamycin	48/98	41/92	59/75	62/50
Moxifloxacin	22/57	5/17	12/13	10/20
Chloramphenicol	0/0	0/0	0/0	0/0
Metronidazole	0/0	0/0	0/0	0/0

*Number of *B. fragilis*/other *B. fragilis* group isolates.
Abbreviations: CU, the Catholic University of Korea; YU, Yonsei University College of Medicine; UU, University of Ulsan College of Medicine; YW, Yonsei University Wonju College of Medicine.

DISCUSSION

This study is the first report of the antimicrobial susceptibility patterns of anaerobic clinical isolates collected from four institutions in Korea. Some results in this study (from YU) have been previously published [7], and these results were reanalyzed together with the data from the other three hospitals. Among the anaerobes identified in clinical specimens, isolates from the *B. fragilis* group are the most commonly encountered and are also more virulent and more resistant to antimicrobial agents than the other anaerobes [10]. Piperacillin was the most active of the ureidopenicillins against the *B. fragilis* group, with the organisms showing 38-48% resistance rates in this study. Piperacillin-tazobactam was active against nearly all strains of the *B. fragilis* group, with only 2-5% resistance rates in this study, in accordance with the less than 7% resistance in previous studies [12-14].

The poor activity of clindamycin against the *B. fragilis* group is recognized worldwide and has been reported in several studies [15-17]. High rates of resistance to clindamycin among *B. fragilis* group isolates have also been reported in Korea [10, 14], and the recent anaerobic isolates tested in this study showed resistance rates of 52-80%. Moxifloxacin was recently introduced for the treatment of skin and soft tissue infections [18]. The resistance rates (12-25%) to moxifloxacin of *B. fragilis* group organisms in this study were slightly higher than the 11-18% rates reported in 2010 in Korea [14] but lower than the 34-55% rates in US hospitals [1].

Jacobus *et al*. [19] reported that the geometric mean MICs of tigecycline for *Parabacteroides distasonis* were significantly higher than those for other *Bacteroides* species. Karlowsky *et al*. [16] noted that 14% of *B. fragilis* isolates and 31% of *B. thetaiotaomicron* isolates were resistant to tigecycline, compared with 5% of *B. fragilis* isolates and 3-7% of other *B. fragilis* group isolates in the study by Snydman *et al*. [15]. Our data showed tigecycline resistance rates of 16-17% for the *B. fragilis* group isolates.

Overall, *Prevotella* and *Fusobacterium* isolates were more susceptible to the antimicrobials than *B. fragilis* group organisms. The resistance rates to moxifloxacin were as low as 24% and 36% for *Prevotella* isolates in Belgium [18] and USA [20], respectively, whereas 44% of *Prevotella* isolates were resistant

http://dx.doi.org/10.3343/alm.2015.35.5.479

to moxifloxacin in this study. Papaparaskevas *et al*. [21] reported that moxifloxacin resistance was prevalent among *Prevotella* and *Bacteroides* species in Greece. Moreover, species variation was noted, with the highest non-susceptible rates being detected among *Prevotella oralis* (90%) and *Prevotella bivia* (80%). The discovery in this study of two *F. magna* isolates that were non-susceptible to chloramphenicol is interesting, since chloramphenicol-resistant anaerobic gram-positive cocci have not been reported.

In this study, there were some differences in the geographical patterns of resistance, and even differences in resistance patterns among the different hospitals in a single city, perhaps due in part to variability in the patterns of prescribing drugs. The CLSI recommends that hospitals conduct at least one annual AST surveillance to elucidate local patterns of resistance. Overall, isolates from UU *B. fragilis* were more resistant to cefoxitin (12% vs. 5%), imipenem (18% vs. 0%), and meropenem (18% vs. 5%) (drugs highly active against group organisms) than those from the other hospitals. The difference in resistance rates among hospitals may be important when selecting appropriate antimicrobial treatment options, although susceptibility testing is not generally performed for individual patient isolates.

Carbapenem resistance is usually mediated by metallo-β-lactamase, which is encoded by the *cfiA* gene in the presence of IS elements that activate the gene [22]. In the present study, two imipenem-resistant *B. fragilis* isolates carried the *cfiA* gene with upstream IS elements.

In conclusion, piperacillin-tazobactam, cefoxitin, imipenem, meropenem, metronidazole, and chloramphenicol remain active against most anaerobic isolates. The 2012 rates of resistance to moxifloxacin and tigecycline for *B. fragilis* group isolates were slightly higher than those reported in 2010 [14]. There were some differences in resistance patterns among the different hospitals. Continuous monitoring is necessary to detect changes in resistance patterns at regional centers and hospitals.

Authors' Disclosures of Potential Conflicts of Interest

No potential conflicts of interest relevant to this article were reported.

Acknowledgments

This study was supported by a CMB-Yuhan research grant of Yonsei University College of Medicine for 2012 (6-2012-0048).

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http://dx.doi.org/10.3343/alm.2015.35.5.479