Antimicrobial resistance patterns for clinical isolates of *Bacteroides fragilis* group organisms isolated in 2009-2012 at a Korean hospital

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Antimicrobial resistance patterns for clinical isolates of *Bacteroides fragilis* group organisms isolated in 2009-2012 at a Korean hospital

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<ABSTRACT>

Antimicrobial resistance patterns for clinical isolates of *Bacteroides fragilis* group organisms isolated during 2009-2012 at a Korean hospital

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Periodic monitoring of antimicrobial resistance trends of clinically important anaerobic bacteria such as *Bacteroides fragilis* group organisms is required, because the resistance patterns may vary greatly depending on regions and routine susceptibility is often not determined. We determined the antimicrobial susceptibilities of clinical isolates of *B. fragilis* group organisms recovered in 2009-2012 in South Korea.

B. fragilis group isolates were recovered from blood, body fluid and abscess specimens at a tertiary-care hospital. The species were identified by conventional methods, the ATB 32A system and MALDI-TOF MS. A total of 180 nonduplicate isolates used in this study were: 86 *B. fragilis*, 46 *B. thetaiotaomicron*, 20 *B. vulgatus*, 13 *B. ovatus*, 13 *Parabacteroides distasonis* and 2 *B. uniformis*. Antimicrobial

susceptibility was determined by the CLSI agar dilution method. The MIC was defined as the concentration at which there was a marked reduction in growth: such as from confluent growth to a haze, less than 10 tiny colonies, or several normal-sized colonies. *B. fragilis* ATCC 25285 and *B. thetaiotaomicron* ATCC 29741 were used as controls.

Cefoxitin, imipenem, and meropenem were highly active against all isolates, with resistance rates of less than 8%. The rate of resistance to piperacillin-tazobactam was 2% for *B. fragilis* and 0% for other *Bacteroides* species, but 13% for *B. thetaiotaomicron* isolates. High resistance rates were observed to piperacillin (67% and 63%), cefotetan (37% and 31%), and clindamycin (78% and 67%) for *B. thetaiotaomicron* isolates and other *Bacteroides* spp., respectively. The moxifloxacin resistance rates were 25% for other *Bacteroides* spp. The MIC range of tigecycline was 0.12-16 μg/mL for all *B. fragilis* group isolates and MIC_{50} and MIC_{90} were 1-2 μg/mL and 8 μg/mL, respectively. No isolates were resistant to chloramphenicol and metronidazole.

Piperacillin-tazobactam, cefoxitin, imipenem, meropenem, chloramphenicol, and metronidazole remain active against *B. fragilis* group isolates. Continuous monitoring is necessary to demonstrate changes in antimicrobial susceptibility patterns of *B. fragilis* group isolates.

Key words : *Bacteroides fragilis* group, antimicrobial resistance, tigecycline, moxifloxacin

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I. INTRODUCTION

Members of the *Bacteroides fragilis* group, the most important anaerobic pathogens often associated with intra-abdominal infection, postoperative wound infection and bacteremia, are also important constituents of the normal colonic microflora.[1-4] And, they are the most antibiotic-resistant isolates among the anaerobic infection and responsible for high rates of morbidity and mortality.[4-6] Over the few past years, increasing resistance of these bacteria to antimicrobial agents has been reported since early 1980s.[1,3,4,6,7] In addition, antimicrobial resistance rates vary among different geographic location and species.[1,2,5,7,8] However, antimicrobial susceptibility testing has been recommended only in particular clinical situations and microorganisms,[8-10] because of the susceptibility testing of anaerobes is technically difficult and time-consuming. For this reason, empirical antimicrobial

therapy of anaerobic infections based on the reports of surveillance studies, thus both periodic and local surveillance studies are needed.

The recent trends of antimicrobial susceptibility pattern of the *B. fragilis* group are reported here in 2009-2012. And the resistance rates were analyzed by CLSI and EUCAST in parallel in order to compare the impact for *B. fragilis* group on antimicrobial susceptibility tests.

II. MATERIALS AND METHODS

1. Bacterial isolates and reference strains

A total of 180 clinical isolates of *B. fragilis* group were recovered in a tertiary care university hospital with 2,086 beds in South Korea from 2009 to 2012. All isolates were identified by conventional method, commercial kit (ATB 32A, ANC, bioMerieux, Marcy I'Etoile, France) and MALDI-TOF MS (bioMerieux, Marcy I'Etoile, France). *B. fragilis* ATCC 25285 and *B. thetaiotaomicron* ATCC 29741 were used as controls.

2. Antimicrobial susceptibility testing

Antimicrobial susceptibility was determined by the CLSI agar dilution method.[10] The medium used was *Brucella* agar (Becton Dickinson, Cockeysville, MD, USA) supplemented with 5 g hemin and 1 g vitamin K_1 per mL and 5% laked sheep blood. The antimicrobial powders used were piperacillin and tazobactam (Yuhan, Seoul), cefoxitin (Merck Sharp & Dohme, West Point, PA, USA), cefotetan (Daiichi Pharmaceutical, Tokyo, Japan), clindamycin (Korea Upjohn, Seoul), imipenem, metronidazole (Choong Wae, Seoul), chloramphenicol (Chong Kun Dang, Seoul), meropenem (Sumitomo, Tokyo, Japan), moxifloxacin (Bayer Korea, Seoul) and tigecycline (Wyeth Research, Pearl River, NY, USA). For the combination of piperacillin and tazobactam, a constant tazobactam concentration of 4 μg/mL was added. An inoculum of 10^5 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 h at 37°C. The MIC was defined as the concentration at which there was a marked reduction in growth: such as from confluent growth to a haze, less than 10 tiny colonies, or several normal-sized colonies.

Clinical breakpoints for interpretation of susceptible or resistant isolates were defined by the Clinical and Laboratory Standards Institute (CLSI) guidelines for all tested antimicrobial agent except tigecycline, and available European Committee on Antimicrobial Susceptibility Testing (EUCAST) breakpoints were also referred as standards. Since neither CLSI nor EUCAST breakpoints are available for tigecycline, the breakpoints recommended by the US Food and Drug Administration (FDA), ≤4 and ≥16 μg/mL, were used.[12]

III. RESULTS

1. Collection and identification of *Bacteroides fragilis* group organisms

From 2009 to 2012, a total of 180 isolates (45 isolates in each year) belonging to *B. fragilis* group were studied. The number of species isolated within the *B. fragilis* group was 86 *B. fragilis*, 46 *B. thetaiotaomicron*, 20 *B. vulgatus*, 13 *B. ovatus*, 13 *Parabacteroides distasonis* and 2 *B. uniformis*. Intra-abdominal infections and bloodstream infections were the most common isolation sources.

2. Antimicrobial susceptibility trend analyzed by CLSI and EUCAST breakpoints

Table 1 summarizes the MIC distributions, as well as the comparison data of percentages of resistant isolates according to CLSI and EUCAST breakpoints.[10,13] Breakpoints of CLSI and EUCAST for all tested antibiotics were different each other, however, none of these differences were significant in antimicrobial resistance rates. For cefoxitin, cefotetan, moxifloxacin and tigecycline, no EUCAST breakpoints are availab

Table 1. Antimicrobial activities against 180 *B. fragilis* group organisms isolated in 2009-2012 at a Korean tertiary care university hospital

Organism (No. of isolates) and antimicrobial agent	MIC (μg/mL)			CLSI (μg/mL)				EUCAST (μg/mL)			
				Breakpoints		Susceptibility %		Breakpoints		Susceptibility %	
	Range	MIC_{50}	MIC_{90}	S	R	S	R	S	R	S	R
***B. fragiles* (86)**											
Piperacillin	1->256	4	>256	≤32	≥128	74	20	≤16	>16	69	31
Piperacillin-tazobactam	≤0.06->128	0.25	1	≤32	≥128	98	2	≤8	>16	98	2
Cefoxitin	2->64	4	16	≤16	≥64	97	2	- †	-	-	-
Cefotetan	1->128	4	32	≤16	≥64	87	6	-	-	-	-
Imipenem	0.03->128	0.06	0.5	≤4	≥16	99	1	≤2	>8	99	1
Meropenem	0.03->128	0.12	2	≤4	≥16	92	1	≤2	>8	91	1
Clindamycin	≤0.03->128	1	128	≤2	≥8	65	35	≤4	>4	65	35
Moxifloxacin	0.12->16	0.25	1	≤2	≥8	92	2	-	-	-	-
Chloramphenicol	2 -> 4	2	4	≤8	≥32	100	0	≤8	>8	100	0
Metronidazole	0.25-> 2	1	2	≤8	≥32	100	0	≤4	>4	100	0
Tigecycline *	0.12->16	1	8	≤4	≥16	85	1	≤4	≥16	85	1
***B. thetaiotaomicron* (46)**											
Piperacillin	8->256	256	256	≤32	≥128	28	67	≤16	>16	24	76
Piperacillin-tazobactam	2->128	8	128	≤32	≥128	83	13	≤8	>16	63	17
Cefoxitin	4->128	16	32	≤16	≥64	85	7	-	-	-	-
Cefotetan	16->128	32	128	≤16	≥64	20	37	-	-	-	-
Imipenem	0.06->16	0.25	4	≤4	≥16	96	2	≤2	>8	87	2
Meropenem	0.06-> 2	0.25	1	≤4	≥16	100	0	≤2	>8	100	0
Clindamycin	2 ->128	128	128	≤2	≥8	17	78	≤4	>4	22	78
Moxifloxacin	0.25->16	1	2	≤2	≥8	98	2	-	-	-	-
Chloramphenicol	2->4	4	4	≤8	≥32	100	0	≤8	>8	100	0
Metronidazole	0.25->2	1	1	≤8	≥32	100	0	≤4	>4	100	0
Tigecycline	0.25->8	2	8	≤4	≥16	87	0	≤4	≥16	87	0

(continued)

Table 1. *(Continued)*

Organism (No. of isolates) and antimicrobial agent	MIC (µg/mL)			CLSI (µg/mL)				EUCAST (µg/mL)			
				Breakpoints		Susceptibility %		Breakpoints		Susceptibility %	
	Range	MIC_{50}	MIC_{90}	S	R	S	R	S	R	S	R
Other *Bacteroides* species (48)											
Piperacillin	1->256	4	>256	≤32	≥128	31	63	≤16	>16	31	69
Piperacillin-tazobactam	≤0.06->128	0.25	1	≤32	≥128	100	0	≤8	>16	88	2
Cefoxitin	2->64	4	16	≤16	≥64	85	6	-	-	-	-
Cefotetan	1->128	4	32	≤16	≥64	52	31	-	-	-	-
Imipenem	0.03->128	0.06	0.5	≤4	≥16	98	2	≤2	>8	98	2
Meropenem	0.03->128	0.12	2	≤4	≥16	98	2	≤2	>8	94	2
Clindamycin	≤0.03->128	1	128	≤2	≥8	31	67	≤4	>4	33	67
Moxifloxacin	0.12->16	0.25	1	≤2	≥8	73	25	-	-	-	-
Chloramphenicol	2 -> 4	2	4	≤8	≥32	100	0	≤8	>8	100	0
Metronidazole	0.25-> 2	1	2	≤8	≥32	100	0	≤4	>4	100	0
Tigecycline	0.12->8	1	8	≤4	≥16	92	0	≤4	≥16	92	0

Abbreviations: MIC, minimum inhibitory concentration; CLSI, Clinical and Laboratory Standards Institute; EUCAST, European Committee on Antimicrobial Susceptibility Testing; S, susceptible; R, resistant

* No CLSI or EUCAST breakpoints available; FDA breakpoints were used.

† No EUCAST breakpoints available

3. Antimicrobial resistance patterns of *Bacteroides fragilis* group organisms in 2009-2012

The percentages of resistant isolates of *B. fragilis* group for each antimicrobial agent in 2009-2012 are illustrated on Table 2. In general, the resistance rates for various antimicrobial agents of the non-*fragilis Bacteroides* species were higher than those of *B. fragilis*. Cefoxitin, imipenem, meropenem and tigecycline, were highly active against all isolates, with resistance rates of less than 8%. Cefoxitin was one of the active β-lactam drugs with resistance rates of 2%, and 7% for *B. fragilis*, both of *B. thetaiotaomicron* and other *Bacteroides* spp, respectively. Imipenem resistance rate was 1%, 2% and 2% for *B. fragilis, B. thetaiotaomicron* and other *Bacteroides* spp., respectively. We found 3 imipenem resistant isolates; one *B. fragilis,* one *B. thetaiotaomicron* and one *P. distasonis*. The resistance rate to meropenem was similar to that of imipenem. The rate of resistance to piperacillin-tazobactam was 2% for *B. fragilis* and 0% for other *Bacteroides* spp. but 13% for *B. thetaiotaomicron* isolates. Compared to the study in 1997-2004, MIC_{90} of piperacillin-tazobactam changed from 16 μg/mL to 128 μg/mL for *B. thetaiotaomicron*, respectively.[6] High resistance rates were observed in piperacillin (67% and 63%), cefotetan (37% and 31%), and clindamycin (78% and 67%) for *B. thetaiotaomicron* isolates and other *Bacteroides* spp., respectively. Piperacillin and clindamycin were less active and most strains tested (90%) were inhibited by these drugs at >256 and ≥128 μg/mL, respectively. CLSI added a recommendation to test susceptibility to moxifloxacin in 2012.[10] In this study, the moxifloxacin resistance rates were 2% for both *B. fragilis* and *B. thetaiotaomicron* isolates, and 25% for other

Table 2. Antimicrobial susceptibility trend of *Bacteroides fragilis* group organisms isolated in 2009-2012

Organism (No. of isolates) and antimicrobial agent	Resistance %			
	2009	2010	2011	2012
***B. fragilis* (86)**	(22)*	(20)	(22)	(22)
Piperacillin	23	35	9	14
Piperacillin-tazobactam	5	5	0	0
Cefoxitin	5	0	0	5
Cefotetan	5	20	0	0
Imipenem	0	5	0	0
Meropenem	0	5	0	0
Clindamycin	32	30	36	41
Moxifloxacin	0	0	9	0
Chloramphenicol	0	0	0	0
Metronidazole	0	0	0	0
Tigecycline	0	0	5	0
***B. thetaiotaomicron* (46)**	(12)	(10)	(12)	(12)
Piperacillin	25	60	83	100
Piperacillin-tazobactam	0	0	33	17
Cefoxitin	8	0	8	8
Cefotetan	17	60	50	25
Imipenem	0	0	0	8
Meropenem	0	0	0	0
Clindamycin	75	100	50	92
Moxifloxacin	0	0	0	8
Chloramphenicol	0	0	0	0
Metronidazole	0	0	0	0
Tigecycline	0	0	0	0
Other *Bacteroides* spp. (48)†	(11)	(15)	(11)	(11)
Piperacillin	55	60	73	64
Piperacillin-tazobactam	0	0	0	0
Cefoxitin	9	7	0	9
Cefotetan	36	33	27	27
Imipenem	0	0	9	0
Meropenem	0	0	9	0
Clindamycin	73	73	45	73
Moxifloxacin	9	27	45	18
Chloramphenicol	0	0	0	0
Metronidazole	0	0	0	0
Tigecycline	0	0	0	0

* Number of isolates.

† The 48 isolates of the *Bacteroides* strains were belong to the following species : *B. vulgatus* (n = 20), *B. ovatus* (n = 13), *P. distasonis* (n = 13), and *B. uniformis* (n = 2).

Bacteroides spp. Tigecycline was one of the most active antimicrobial agentsamong the non-β lactam agents, the resistance rate were 1%, 0% and 0% for *B. fragilis, B. thetatiotaomicron* and other *Bacteroides* species, respectively. And the intermediate resistance rates were 14%, 13% and 8% for *B. fragilis, B. thetatiotaomicron* and other *Bacteroides* species, respectively (not shown in table 2). The MIC range of tigecycline was 0.12 - 16 μg/mL for all *B. fragilis* group isolates. Only one isolate among all strains, proved to be resistant, was *B. fragilis* and the MIC was 16μg/mL. All the isolates were inhibited by ≤4 μg/mL of chloramphenicol or metronidazole, to which no isolates were resistant.

4. Trends of antimicrobial susceptibility of *Bacteroides fragilis* group organisms

The resistance rate trends in 1989-1990,1997-2004 and 2009-2012 of *B. fragilis* group organisms to eight antimicrobial agents are shown in Figure 1. In our previous studies, the resistance rates to various antimicrobial agents of the non-*fragilis Bacteroides* species were also higher than those of *B. fragiles,* which is similar to the results of this study. Piperacillin activity against *B. thetaiotaomicron* and other *Bacteroides* spp. have been increasing, were higher from 2009 through 2012 (67% and 63%) than they were from 1997 through 2004 (42% and 49%). However, cefotetan activity against *B. thetaiotaomicron* and other *Bacteroides* spp. have shown decreasing trend during this period. Of interest, the resistance rates to piperacillin, cefotetan and clindamycin for *B. fragilis* were still high, however the overall resistance rate to these three

antibiotics decreased when compared to our previous study in 1997-2004.[6] There were no resistant isolates to carbepenems for *B. fragilis* group species in the study of 1989-1990,[14] although the level of carbapenems resistance has not changed dramatically during the past 25 years, the percentage of isolates with reduced susceptibilities has increased steadily.

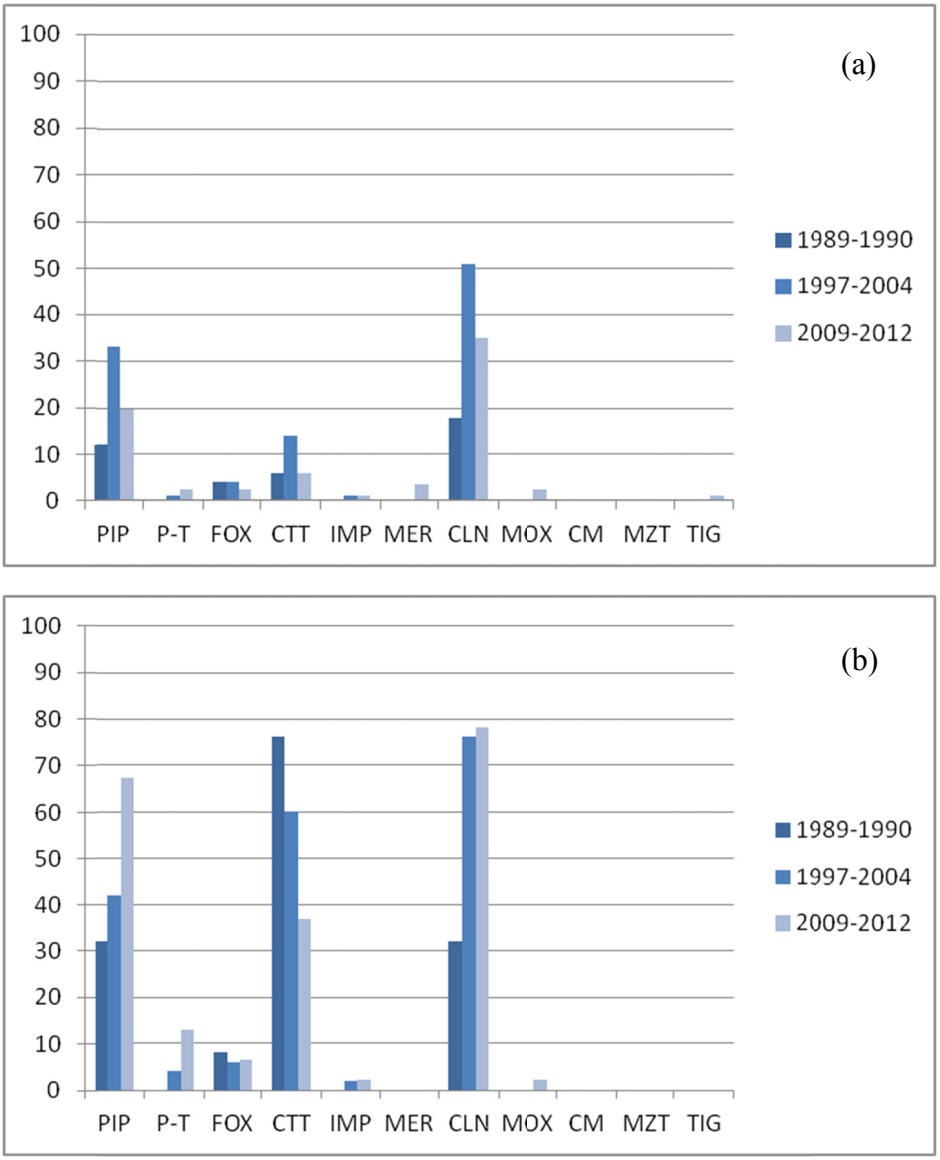

Figure 1. Trends in resistance rate of *Bacteroides fragilis* group isolates in 1989-1990, 1997-2004 and 2009-2012 *(continued)*

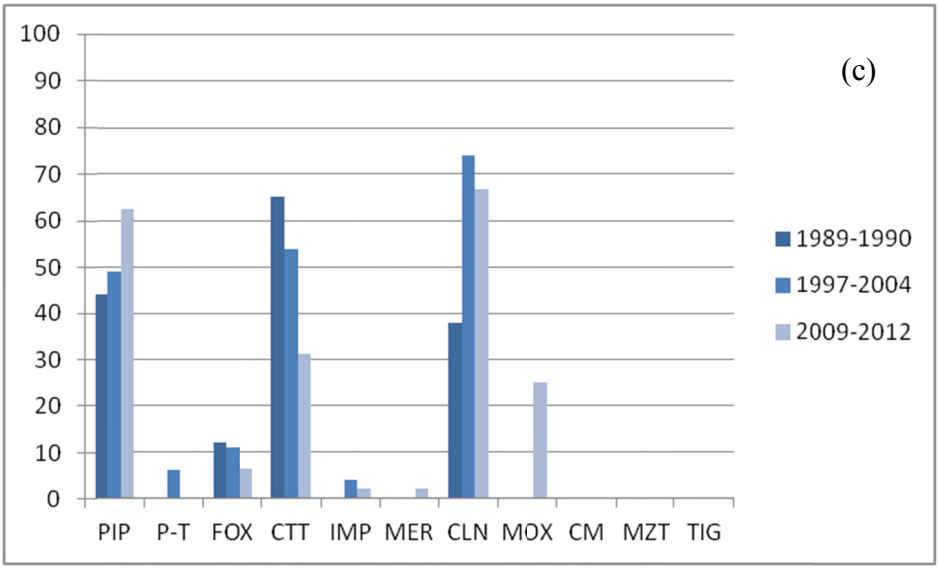

Figure 1. *(continued)*

X-axis: antimicrobial agents

Y-axis: the percentage of each antimicrobial resistant isolates

(a) *B. fragilis*

(b) *B. thetaiotaomicron*

(c) Other *Bacteroides* species

Abbreviations: PIP, piperacillin; P-T, piperacillin-tazobactam; FOX, cefoxitin; CTT, cefotetan; IMP, imipenem; MER, meropenem; CLN, clindamycin; MOX, moxifloxacin; CM, chloramphenicol; MZT, metronidazole; TIG, tigecycline

IV. DISCUSSION

Although the members of the *B. fragilis* group are considered the most important anaerobic pathogen, susceptibility testing results had not been used widely for making clinical decisions. Mostly because of the availability of broad-spectrum antibiotics in mixed infections, slow growth of the bacteria, complexity of the testing methods and the belief of the susceptibility patterns among anaerobes can be predictable.[15,16] However, in recent years there has been a reduction in the susceptibility of anaerobes and antimicrobial susceptibility test results are still indispensible in selected groups of individual patients, because the clinical outcome correlates with these results.[16,17]

Similar to previous studies from USA and various European countries, the present study shows the variability of susceptibility patterns among *B. fragilis* group species. There are two widely used criteria to determine the susceptibility for specific microorganism to specific antimicrobial agents, which is CLSI and EUCAST. To understand the impact of using CLSI or EUCAST clinical breakpoints for the resistance rates, we evaluated resistance rates for all isolates using either CLSI or EUCAST breakpoints. The concentrations of CLSI breakpoints were high than those of EUCAST for most of all tested antibiotics in present study. We expected the higher resistance rates according to the EUCAST breakpoints, however, there were no significant difference in the resistance profile. The tendencies were similar in Europe for piperacillin-tazobactam, which showed relatively high resistance rate and high concentration of MIC_{90} (128 μg/mL) in *B. thetaiotaomicron*.[3] Whereas, other countries such as USA, Canada, Argentina reported low resistance rates in all *B.*

fragilis group isolates.[2,8,18] Carbapenems are usually highly active to the *B. fragilis* group isolates. Compared to our previous work in 1989-1996,[14] there were no resistance isolates in 1989-1996 but recently some resistance isolates are emerging although they are still active antibiotics to *B. fragilis* groups. The resistance rates for carbapenems in Europe, USA, Canada were also reported about 1%, but the recent multicenter survey in German by Harald Seifert et al.[7] showed very high resistance rate (8% for ertapenem and 7.5% for meropenem) among *B. fragilis*.

As shown in Figure 1, the resistance rates were usually higher in non-*B. fragilis* species than *B. fragilis* to most of antibiotics. No dramatic changes in piperacillin, cefotetan and clindamycin resistance were confirmed over the years, it is clear that these antibiotics should no longer be used without prior susceptibility testing. For the cefotetan, decreasing resistance of all *B. fragilis* group was observed although still not low level. In contrast, the continuing trend towards increasing resistance of the *B. thetaiotaomicron* and other *Bacteroides* group spp. to piperacillin was revealed.

In contrast to the earlist fluoroquinolones, several newer fluoroquinolones, one of them was moxifloxacin, showed good in vitro activity against most anaerobic bacteria when first introduced.[19] However, during recent years various surveys have reported an increase in even to newer fluoroquinolones resistance among *Bacteroides* spp.[2,3,7,18,20-21] Our previous studies have also reported that increase in resistance against moxifloxacin in *Bacteroides* species and also demonstrated 11-20% resistance rate in *B. fragilis*.[9,22] However, unlike other studies, our present data for moxifloxacin showed low resistance (both were 2%) among *B. fragilis* and *B. thetaiotaomicron* and relatively high resistance rate (25%) in other *Bacteroides* species (Table 2). It has

been suggested that these differences may be attributed to differences in patterns of antibiotics use and different patient populations investigated. Metronidazole and chloramphenicol resistance in *B. fragilis* group isolates has recently been reported worldwide.[3,7,19,22,24] The resistance rate to metronidazole were reported less than 1% in recent European and USA study,[3,18] but it has been increasingly reported in many other European countries, about 1%.[7] However, there have not been resistant isolates of *B. fragilis* group for these agents reported in Korea. In concordance with previous reports,[6,9,14,22] susceptibility patterns for these antibiotics remained stable.

Tigecycline proved highly active in this study and it was similar to the reported data from other countries.[3,8,18] However, relatively high percentage of intermediate resistance rates were revealed in this study (14%, 13% and 8% for *B. fragilis, B. thetaiotaomicron* and other *Bacteroides* species, respectively), which may imply to reduced susceptibility in the recent future.

V. CONCLUSION

Piperacillin-tazobactam, imipenem, meropenem, chloramphenicol and metronidazole remain active against *B. fragilis* group isolates. Moxifloxacin revealed low resistance among *B. fragilis* and *B. thetaiotaomicron*, while relatively high resistance rates in other *Bacteroides* spp. Therefore, continuous monitoring is necessary to demonstrate changes in antimicrobial susceptibility patterns of *B. fragilis* group isolates.

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< ABSTRACT (IN KOREAN)>

국내 임상검체 분리 *Bacteroides fragilis* 군의 항균제 내성 연구(2009-2012)

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임상적으로 중요한 무산소성 세균인 *Bacteroides fragilis*군 세균은 그 내성 비율이 지역과 균종에 따라 달라, 주기적인 항균제 내성 양상의 감시가 중요하다. 본 연구에서는 2009년부터 2012년까지 국내 임상 검체에서 수집된 *B. fragilis*군 세균을 대상으로 항균제 내성 양상을 분석하였다.

*B. fragilis*군 세균은 국내 한 삼차 병원에 내원한 환자의 혈액, 체액 및 농양 검체에서 분리하였다. 각각의 균주는 *B. fragilis* 86주, *B. thetaiotaomicron* 46주, *B. vulgatus* 20주, *B. ovatus* 13주, *Parabacteroides distasonis* 13주, 그리고 *B. uniformis*가 2주였다.

혐기성 세균은 전통적인 생화학 방법, ATB 32A system (bioMerieux, Marcy l'Etoile, France)그리고 MALDI-TOF MS를 비교 동정 하였다. 각

연도별로 45주씩, 총 180주를 수집하였고, 항균제 감수성 검사는 Clinical and Laboratory Standard Institute (CLSI)의 한천 희석법(2012)으로 시행하였다. 정도 관리를 위해서 *B. fragilis* ATCC 25285 와 *B. thetaiotaomicron* ATCC 29741을 사용하였다.

Cefoxitin, imipenem 및 meropenem 에 대한 내성률은 모든 균종에 대하여 8%이내로 높은 감수성을 보였다. *B. fragilis*균종과 다른 *Bacteroides* 균종은 piperacillin-tazobactam에 대하여 각각 2%, 0%의 내성률을 보였으나, *B. thetaiotaomicron*은 13%의 내성률을 보였다. *B. thetaiotaomicron*과 다른 *Bacteroides* 균종은 piperacillin (67% 및 63%), cefotetan (37% 및 31%) 및 clindamycin (78% 및 67%)에 높은 내성률을 나타내었다. 다른 *Bacteroides* 균종은 moxifloxacin 에 대하여 25%로 높은 내성률을 보였다. *B. fragilis*군 세균에 대한 Tigecycline의 MIC 범위는 0.12-16 μg/mL였고, 시험한 모든 균주에서 MIC_{50}은 1-2 μg/mL, MIC_{90} 은 8 μg/mL였다. 모든 균이 Chloramphenicol과 metronidazole에 감수성으로 나타났다.

결론적으로, piperacillin-tazobactam, cefoxitin, imipenem, meropenem, chloramphenicol 그리고 metronidazole은 국내 분리 *B. fragilis* 군 세균에 우수한 항균력을 보였다. 항균제 내성 양상의 변화에 대한 감시와 무산소성 세균 감염의 효과적 치료를 위해 앞으로도 이러한 무산소성 세균에 대한 지속적인 항균제 내성 연구가 필요하다.

핵심되는 말 : *Bacteroides fragilis* 군, 항균제 내성, tigecycline, moxifloxacin