Antimicrobial Susceptibility Patterns of Anaerobic Bacterial Clinical Isolates From 2014 to 2016, Including Recently Named or Renamed Species

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Background: Anaerobic bacterial resistance trends may vary across regions or institutions. Regional susceptibility patterns are pivotal in the empirical treatment of anaerobic infections. We determined the antimicrobial resistance patterns of clinically important anaerobic bacteria, including recently named or renamed anaerobes.

Methods: A total of 521 non-duplicated clinical isolates of anaerobic bacteria were collected from a tertiary-care hospital in Korea between 2014 and 2016. Anaerobes were isolated from blood, body fluids, and abscess specimens. Each isolate was identified by conventional methods and by Bruker biotyper mass spectrometry (Bruker Daltonics, Leipzig, Germany) or VITEK matrix-assisted laser desorption ionization time-of-flight mass spectrometry (bioMérieux, Marcy-l’Étoile, France). Antimicrobial susceptibility was tested using the agar dilution method according to the CLSI guidelines. The following antimicrobials were tested: piperacillin-tazobactam, cefoxitin, cefotetan, imipenem, meropenem, clindamycin, moxifloxacin, chloramphenicol, tetracycline, and metronidazole.

Results: Most Bacteroides fragilis isolates were susceptible to piperacillin-tazobactam, cefoxitin, cefotetan, imipenem, meropenem, clindamycin, moxifloxacin, chloramphenicol, tetracycline, and metronidazole. The non-fragilis Bacteroides group (including B. intestinalis, B. nordii, B. pyogenes, B. stercoris, B. salyersiae, and B. cellulositlyticus) was resistant to meropenem (14%) and cefotetan (71%), and Parabacteroides distasonis was resistant to imipenem (11%) and cefotetan (95%). Overall, the Prevotella and Fusobacterium isolates were more susceptible to antimicrobial agents than the B. fragilis group isolates. Anaerobic gram-positive cocci exhibited various resistance rates to tetracycline (6–86%). Clostridioides difficile was highly resistant to penicillin, cefoxitin, imipenem, clindamycin, and moxifloxacin.

Conclusions: Piperacillin-tazobactam, cefoxitin, and carbapenems are highly active β-lactam agents against most anaerobes, including recently named or renamed species.

Key Words: Antimicrobial resistance pattern, Anaerobes, Bacteroides, Korea

INTRODUCTION

The prevalence of antibiotic resistance in anaerobes is increasing, which impacts both antibiotic treatment and patient mortality [1]. Regional susceptibility patterns are pivotal in the empirical treatment of anaerobic infections. As the resistance trends of anaerobic bacteria may vary greatly, across regions or institutions [2-4], antimicrobial susceptibility tests (ASTs) should be performed to assist with empirical antimicrobial treatment of anaerobic infections.
The CLSI has stated that routine ASTs for anaerobes are not necessary, because antibiotic resistance is often predictable [5]. Therefore, we do not always perform ASTs; however, since 1989, we have been performing periodic ASTs to investigate resistance trends among clinical bacterial isolates [6-9].

Anaerobic gram-negative bacilli (GNB) are clinically important because they have high resistance rates relative to other anaerobic bacteria [10]. Recently, a related cluster of multidrug-resistant Bacteroides fragilis isolates were recovered from several patients, which resulted in treatment failure in some cases [11, 12]. Furthermore, a number of anaerobic species have recently been named or renamed. Parabacteroides distasonis and P. goldsteinii were reclassified from the genus Bacteroides; Atloscardovia omnicolens, Bulleidia extuncta, Leptotrichia trevisanii, Alistipes finegoldii, and Alistipes onderdonkii were named in the 2000s [13-18]. Moreover, AST data for infrequently isolated species are quite limited. Therefore, we collected rarely isolated anaerobic bacteria from clinical specimens and evaluated them using ASTs. In addition, we determined the antimicrobial resistance patterns of clinically important anaerobic bacteria, including recently named or renamed anaerobes.

METHODS

Bacterial isolates
A total of 521 non-duplicated clinical anaerobic bacteria isolates were collected from a tertiary-care hospital (Severance Hospital, Seoul, Korea) between 2014 and 2016. Anaerobes were isolated from blood, body fluids, and abscess specimens. Each isolate was identified by conventional methods, Bruker biotyper mass spectrometry (Bruker Daltonics, Leipzig, Germany), or VITEK matrix-assisted laser desorption ionization time-of-flight mass spectrometry (bioMérieux, Marcy-l’Étoile, France).

We tested a total of 230 gram-negative isolates, including 60 Bacteroides fragilis, 68 non-fragilis Bacteroides spp., 29 Parabacteroides spp., 33 Prevotella spp., 19 Fusobacterium spp., 10 other anaerobic GNB, and 11 Veillonella spp. Non-fragilis Bacteroides isolates were divided into two groups as follows: Group I included B. thetaiotaomicron, B. caccae, B. uniformis, B. vulgatus, and B. ovatus; Group II were recently classified, renamed, or infrequently isolated including B. intestinalis, B. nordii, B. pyogenes, B. stercoris, B. salyersiae, and B. cellulosilyticus. A total of 291 gram-positive isolates were tested, including 31 Finegoldia magna, 29 Parvimonas micra, 14 other gram-positive cocci (GPC), 15 Clostridoides difficile, 27 Clostridium spp., 34 Actinomyces odontolyticus, 23 Actinomyces spp., 18 Bifidobacterium spp., 38 Eggerthella lenta, 36 Lactobacillus spp., and 26 other gram-positive bacilli.

ASTs
ASTs were conducted using the agar dilution method, and minimum inhibitory concentrations (MICs) were interpreted according to the CLSI guidelines [5, 19]. The medium used was Brucella agar (Becton Dickinson, Cockeysville, MD, USA) supplemented with 5 µg/mL hemin, 1 µg/mL vitamin K₁, and 5% laked sheep blood. The following antimicrobials were tested: penicillin (Sigma Aldrich, Yongin, Korea), piperacillin-tazobactam (Yuhan, Seoul, Korea), cefoxitin (Merck Sharp & Dohme, West Point, PA, USA), cefotetan (Daichi Pharmaceutical, Tokyo, Japan), imipenem and meropenem (Sanoil, Daewoong, Korea), clindamycin (Korea Upjohn, Seoul, Korea), amoxicillin (Sumitomo, Tokyo, Japan), moxifloxacin (Bayer Korea, Seoul, Korea), chloramphenicol (Chong Kun Dang, Seoul, Korea), and tetracycline (Sigma Aldrich). For the piperacillin and tazobactam combination, a constant concentration of tazobactam (4 µg/mL) was added. An inoculum of 10⁵ colony forming units (CFUs) 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 hours at 37°C. Quality control was tested with the following two organisms: B. fragilis ATCC 25285 and B. thetaiotaomicron ATCC 29741. Double-disk potentiation tests (DPTs) with dipicolinic acid were carried out on Brucella agar to screen for carbapenemase-producing B. fragilis group isolates [20].

RESULTS

Anaerobic gram-negative isolates
Most of the gram-negative isolates tested were susceptible to piperacillin-tazobactam, imipenem, and meropenem, as their resistance rates to these three antimicrobials were <7% (Table 1). Low frequencies of resistance to chloramphenicol and metronidazole were observed for most of the anaerobic gram-negative bacterial isolates tested.

High rates of resistance to penicillin (98–100%), cefotetan (12–71%), and clindamycin (38–69%) were noted for the B. fragilis group isolates. The resistance of B. fragilis isolates to cefotetan was 12%; however, the non-fragilis Bacteroides Group II isolates showed high resistance to cefotetan (71%). Furthermore, Parabacteroides spp. (including P. distasonis), reclassified from the genus Bacteroides, showed very high resistance to cefotetan (95–100%). The resistance of B. fragilis and non-fran-
### Table 1. Antimicrobial susceptibility of 521 anaerobic bacterial isolates from 2014 to 2016

| N of isolates and antimicrobial agents | Breakpoint (µg/mL) | MIC (µg/mL) | Susceptibility (%)* |
|---------------------------------------|-------------------|-------------|---------------------|
|                                       | S     | I       | R       | Range | 50% | 90% | S | I | R |
| Bacteroides fragilis (60)             |       |         |         |        |     |     |    |    |    |
| Penicillin                            | ≤ 0.5 | 1       | ≥ 2     | 4→128  | 16  | >128| 0 | 0 | 100 |
| Piperacillin-tazobactam               | ≤ 32  | 64      | ≥ 128   | 0.12→128| 1   | 4   | 95 | 0 | 5  |
| Cefoxitin                             | ≤ 16  | 32      | ≥ 64    | 4→64   | 8   | 32  | 82 | 12| 7  |
| Cefotetan                             | ≤ 16  | 32      | ≥ 64    | 2→128  | 8   | 64  | 75 | 13| 12 |
| Imipenem                              | ≤ 4   | 8       | ≥ 16    | ≤ 0.06→32| 0.12| 1   | 95 | 0 | 5  |
| Meropenem                             | ≤ 4   | 8       | ≥ 16    | ≤ 0.06→128| 0.12| 2   | 92 | 3 | 5  |
| Clindamycin                           | ≤ 2   | 4       | ≥ 8     | ≤ 0.06→128| 1   | >128| 60 | 2 | 38 |
| Moxifloxacin                          | ≤ 2   | 4       | ≥ 8     | ≤ 0.06→32| 0.5 | 8   | 77 | 3 | 20 |
| Chloramphenicol                       | ≤ 8   | 16      | ≥ 32    | 4→8    | 4   | 8   | 100| 0 | 0  |
| Metronidazole                         | ≤ 8   | 16      | ≥ 32    | 0.25→8 | 4   | 4   | 100| 0 | 0  |

| Non-fragilis Bacteroides group I (54)*|       |         |         |        |     |     |    |    |    |
| Penicillin                            | ≤ 0.5 | 1       | ≥ 2     | ≤ 0.06→128| 128 | >128| 2 | 0 | 98 |
| Piperacillin-tazobactam               | ≤ 32  | 64      | ≥ 128   | ≤ 0.06→128| 8   | 32  | 93 | 2 | 6  |
| Cefoxitin                             | ≤ 16  | 32      | ≥ 64    | 1→128  | 16  | 32  | 57 | 35| 7  |
| Cefotetan                             | ≤ 16  | 32      | ≥ 64    | 0.5→128 | 64  | >128| 17 | 24| 59 |
| Imipenem                              | ≤ 4   | 8       | ≥ 16    | ≤ 0.06→32| 0.5 | 2   | 94 | 4 | 2  |
| Meropenem                             | ≤ 4   | 8       | ≥ 16    | ≤ 0.06→128| 0.5 | 2   | 100| 0 | 0  |
| Clindamycin                           | ≤ 2   | 4       | ≥ 8     | ≤ 0.06→128| >128| >128| 20 | 11| 69 |
| Moxifloxacin                          | ≤ 2   | 4       | ≥ 8     | ≤ 0.06→32| 2   | 8   | 78 | 7 | 15 |
| Chloramphenicol                       | ≤ 8   | 16      | ≥ 32    | 2→8    | 8   | 8   | 100| 0 | 0  |
| Metronidazole                         | ≤ 8   | 16      | ≥ 32    | 0.5→8  | 2   | 4   | 100| 0 | 0  |

| Non-fragilis Bacteroides group II (14)*|       |         |         |        |     |     |    |    |    |
| Penicillin                            | ≤ 0.5 | 1       | ≥ 2     | 16→128 | 16  | >128| 0 | 0 | 100 |
| Piperacillin-tazobactam               | ≤ 32  | 64      | ≥ 128   | 0.5→32 | 8   | 32  | 100| 0 | 0  |
| Cefoxitin                             | ≤ 16  | 32      | ≥ 64    | 1→64   | 32  | 32  | 43 | 50| 7  |
| Cefotetan                             | ≤ 16  | 32      | ≥ 64    | 4→128  | 64  | 128 | 21 | 7 | 71 |
| Imipenem                              | ≤ 4   | 8       | ≥ 16    | 0.12→2 | 0.25| 2   | 100| 0 | 0  |
| Meropenem                             | ≤ 4   | 8       | ≥ 16    | 0.12→32| 0.25| 16  | 86 | 0 | 14 |
| Clindamycin                           | ≤ 2   | 4       | ≥ 8     | 0.5→128| >128| >128| 36 | 0 | 64 |
| Moxifloxacin                          | ≤ 2   | 4       | ≥ 8     | 0.5→64 | 1   | 16  | 79 | 0 | 21 |
| Chloramphenicol                       | ≤ 8   | 16      | ≥ 32    | 4→8    | 8   | 8   | 100| 0 | 0  |
| Metronidazole                         | ≤ 8   | 16      | ≥ 32    | 2→4    | 2   | 4   | 100| 0 | 0  |

| Parabacteroides distasonis (19)       |       |         |         |        |     |     |    |    |    |
| Penicillin                            | ≤ 0.5 | 1       | ≥ 2     | ≤ 0.06→128| >128| >128| 5 | 0 | 95 |
| Piperacillin-tazobactam               | ≤ 32  | 64      | ≥ 128   | ≤ 0.06→128| 32  | >128| 89 | 0 | 11 |
| Cefoxitin                             | ≤ 16  | 32      | ≥ 64    | 1→128  | 32  | 64  | 21 | 42| 37 |
| Cefotetan                             | ≤ 16  | 32      | ≥ 64    | 1→128  | 128 | >128| 5  | 0 | 95 |
| Imipenem                              | ≤ 4   | 8       | ≥ 16    | ≤ 0.06→64| 1   | 16  | 89 | 0 | 11 |
| Clindamycin                           | ≤ 2   | 4       | ≥ 8     | ≤ 0.06→128| >128| >128| 5  | 16| 79 |

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Table 1. Continued

| N of isolates and antimicrobial agents | Breakpoint (µg/mL) | MIC (µg/mL) | Susceptibility (%)* |
|---------------------------------------|-------------------|-------------|---------------------|
|                                       | S | I | R | Range | 50% | 90% | S | I | R |
| Moxifloxacin                          | ≤ 2 | 4 | ≥ 8 | 0.12–32 | 0.5 | 16 | 79 | 0 | 21 |
| Chloramphenicol                      | ≤ 8 | 16 | ≥ 32 | 2–8 | 8 | 8 | 100 | 0 | 0 |
| Metronidazole                        | ≤ 8 | 16 | ≥ 32 | 0.5–4 | 2 | 4 | 100 | 0 | 0 |
| Parabacteroides spp. (10)§           | Penicillin       | ≤ 0.5 | 1 | ≥ 2 | 8–128 | 128 | 128 | 0 | 0 | 100 |
|                                      | Piperacillin-tazobactam | ≤ 32 | 64 | ≥ 128 | 2–32 | 16 | 32 | 100 | 0 | 0 |
|                                      | Cefotixin        | ≤ 16 | 32 | ≥ 64 | 16–64 | 32 | 64 | 20 | 50 | 30 |
|                                      | Cefotetan        | ≤ 16 | 32 | ≥ 64 | 64–128 | 128 | 128 | 0 | 0 | 100 |
|                                      | Imipenem         | ≤ 4 | 8 | ≥ 16 | 1–4 | 1 | 4 | 100 | 0 | 0 |
|                                      | Clindamycin      | ≤ 2 | 4 | ≥ 8 | 0.5–128 | 128 | 128 | 20 | 0 | 80 |
|                                      | Moxifloxacin     | ≤ 2 | 4 | ≥ 8 | 0.25–16 | 0.5 | 16 | 60 | 10 | 30 |
|                                      | Chloramphenicol  | ≤ 8 | 16 | ≥ 32 | 4–8 | 8 | 8 | 100 | 0 | 0 |
|                                      | Metronidazole    | ≤ 8 | 16 | ≥ 32 | 1–4 | 2 | 4 | 100 | 0 | 0 |
| Prevotella spp. (33)ǁ                 | Penicillin       | ≤ 0.5 | 1 | ≥ 2 | 0.06–128 | 16 | 32 | 6 | 3 | 91 |
|                                      | Piperacillin-tazobactam | ≤ 32 | 64 | ≥ 128 | 0.06–8 | ≤ 0.06 | ≤ 0.06 | 100 | 0 | 0 |
|                                      | Cefotixin        | ≤ 16 | 32 | ≥ 64 | 0.5–32 | 1 | 4 | 97 | 0 | 0 |
|                                      | Cefotetan        | ≤ 16 | 32 | ≥ 64 | 0.5–64 | 2 | 32 | 88 | 9 | 3 |
|                                      | Imipenem         | ≤ 4 | 8 | ≥ 16 | 0.06–1 | ≤ 0.06 | ≤ 0.06 | 100 | 0 | 0 |
|                                      | Clindamycin      | ≤ 2 | 4 | ≥ 8 | 0.06–128 | 0.06–128 | 0.06–128 | 55 | 0 | 45 |
|                                      | Moxifloxacin     | ≤ 2 | 4 | ≥ 8 | 0.12–64 | 0.5 | 4 | 70 | 21 | 9 |
|                                      | Chloramphenicol  | ≤ 8 | 16 | ≥ 32 | 1–16 | 2 | 8 | 91 | 9 | 0 |
|                                      | Metronidazole    | ≤ 8 | 16 | ≥ 32 | 0.12–32 | 1 | 8 | 91 | 6 | 3 |
| Fusobacterium spp. (19)¶              | Penicillin       | ≤ 0.5 | 1 | ≥ 2 | 0.06–128 | 0.25 | 4 | 79 | 5 | 16 |
|                                      | Piperacillin-tazobactam | ≤ 32 | 64 | ≥ 128 | 0.06–8 | 2 | 4 | 100 | 0 | 0 |
|                                      | Cefotixin        | ≤ 16 | 32 | ≥ 64 | 0.12–16 | 4 | 8 | 100 | 0 | 0 |
|                                      | Cefotetan        | ≤ 16 | 32 | ≥ 64 | 0.06–32 | 2 | 4 | 95 | 5 | 0 |
|                                      | Imipenem         | ≤ 4 | 8 | ≥ 16 | 0.06–4 | 1 | 2 | 100 | 0 | 0 |
|                                      | Meropenem        | ≤ 4 | 8 | ≥ 16 | 0.06–2 | 0.06–1 | 0.06–1 | 100 | 0 | 0 |
|                                      | Clindamycin      | ≤ 2 | 4 | ≥ 8 | 0.06–128 | 2 | 16 | 58 | 21 | 21 |
|                                      | Moxifloxacin     | ≤ 2 | 4 | ≥ 8 | 0.06–128 | 4 | 8 | 42 | 47 | 11 |
|                                      | Chloramphenicol  | ≤ 8 | 16 | ≥ 32 | 0.06–2 | 2 | 2 | 100 | 0 | 0 |
|                                      | Metronidazole    | ≤ 8 | 16 | ≥ 32 | 0.12–1 | 0.06 | 1 | 100 | 0 | 0 |

Other gram-negative bacilli (10)**

| Penicillin       | ≤ 0.5 | 1 | ≥ 2 | 0.06–128 | 1 | 16 | 30 | 30 | 40 |
| Piperacillin-tazobactam | ≤ 32 | 64 | ≥ 128 | 0.06–128 | 1 | 128 | 80 | 0 | 20 |
| Cefotixin        | ≤ 16 | 32 | ≥ 64 | 0.25–32 | 2 | 32 | 80 | 20 | 0 |
| Cefotetan        | ≤ 16 | 32 | ≥ 64 | 0.5–32 | 2 | 4 | 90 | 10 | 0 |
| Imipenem         | ≤ 4 | 8 | ≥ 16 | 0.06–0.5 | 0.25 | 0.25 | 100 | 0 | 0 |

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| N of isolates and antimicrobial agents | Breakpoint (µg/mL) | MIC (µg/mL) | Susceptibility (%)* |
|--------------------------------------|-------------------|-------------|---------------------|
|                                       | S     | I    | R    | Range | 50% | 90% | S | I | R |
| Clindamycin                          | ≤ 2   | 4    | ≥ 8  | ≤ 0.06–32 | ≤ 0.06 | 4         | 90 | 0 | 10 |
| Moxifloxacin                         | ≤ 2   | 4    | ≥ 8  | ≤ 0.06–16 | 0.5 | 16       | 50 | 10 | 40 |
| Chloramphenicol                      | ≤ 8   | 16   | ≥ 32 | 0.25–8  | 4 | 8        | 100 | 0 | 0  |
| Metronidazole                        | ≤ 8   | 16   | ≥ 32 | ≤ 0.06–64 | NA | NA       | NA | NA | NA |
| Veillonella spp. (11)**              |       |      |      |         |     |          |     |     |     |
| Penicillin                           | ≤ 0.5 | 1    | ≥ 2  | 2–16   | 4 | 16       | 0  | 0 | 100|
| Piperacillin-tazobactam              | ≤ 32  | 64   | ≥ 128| 4–128  | 16 | 32       | 91 | 0 | 9 |
| Cefoxitin                            | ≤ 16  | 32   | ≥ 64 | 0.25–4 | 0.5 | 2        | 91 | 0 | 0 |
| Cefotetan                            | ≤ 4   | 8    | ≥ 16 | 0.25–8 | 0.50 | 2        | 91 | 0 | 0 |
| Clindamycin                          | ≤ 2   | 4    | ≥ 8  | ≤ 0.06–>128 | ≤ 0.06 | 2         | 91 | 0 | 9 |
| Moxifloxacin                         | ≤ 2   | 4    | ≥ 8  | ≤ 0.06–64 | 0.25 | 4        | 82 | 9 | 9 |
| Chloramphenicol                      | ≤ 8   | 16   | ≥ 32 | 0.5–2  | 2 | 2        | 100 | 0 | 0 |
| Metronidazole                        | ≤ 8   | 16   | ≥ 32 | 2–32   | 8 | 32       | 73 | 0 | 27|
| Finegoldia magna (31)                |       |      |      |         |     |          |     |     |     |
| Penicillin                           | ≤ 0.5 | 1    | ≥ 2  | ≤ 0.06–0.12 | ≤ 0.06 | ≤ 0.06 | 100 | 0 | 0 |
| Piperacillin-tazobactam              | ≤ 32  | 64   | ≥ 128| ≤ 0.06–0.12 | ≤ 0.06 | ≤ 0.06 | 100 | 0 | 0 |
| Cefoxitin                            | ≤ 16  | 32   | ≥ 64 | 0.25–4 | 0.5 | 2        | 100 | 0 | 0 |
| Cefotetan                            | ≤ 4   | 8    | ≥ 16 | 0.25–4 | 0.5 | 2        | 100 | 0 | 0 |
| Clindamycin                          | ≤ 2   | 4    | ≥ 8  | ≤ 0.06–0.06 | ≤ 0.06 | ≤ 0.06 | 100 | 0 | 0 |
| Moxifloxacin                         | ≤ 2   | 4    | ≥ 8  | ≤ 0.06–0.64 | 0.25 | 0.5       | 94 | 3 | 3 |
| Metronidazole                        | ≤ 8   | 16   | ≥ 32 | 0.12–8 | 2 | 2        | 94 | 0 | 6 |
| Tetracycline                         | ≤ 4   | 8    | ≥ 16 | 0.12–8 | 1 | 1        | 100 | 0 | 0 |
| Parvimonas micra (29)                |       |      |      |         |     |          |     |     |     |
| Penicillin                           | ≤ 0.5 | 1    | ≥ 2  | ≤ 0.06–0.25 | 0.12 | 0.25       | 100 | 0 | 0 |
| Piperacillin-tazobactam              | ≤ 32  | 64   | ≥ 128| ≤ 0.06–2 | 0.12 | 0.25       | 100 | 0 | 0 |
| Cefoxitin                            | ≤ 16  | 32   | ≥ 64 | 0.25–4 | 0.5 | 1        | 100 | 0 | 0 |
| Cefotetan                            | ≤ 4   | 8    | ≥ 16 | 0.25–4 | 1 | 2        | 100 | 0 | 0 |
| Imipenem                             | ≤ 4   | 8    | ≥ 16 | ≤ 0.06–0.25 | ≤ 0.06 | 0.12       | 100 | 0 | 0 |
| Clindamycin                          | ≤ 2   | 4    | ≥ 8  | ≤ 0.06–128 | 1 | 128       | 76 | 0 | 24 |
| Moxifloxacin                         | ≤ 2   | 4    | ≥ 8  | ≤ 0.06–32 | 2 | 32        | 52 | 0 | 48 |
| Metronidazole                        | ≤ 8   | 16   | ≥ 32 | 0.5–4  | 1 | 2        | 100 | 0 | 0 |
| Tetracycline                         | ≤ 4   | 8    | ≥ 16 | 1–64   | 16 | 32       | 45 | 0 | 55 |
| Other gram-positive cocci (14)**     |       |      |      |         |     |          |     |     |     |
| Penicillin                           | ≤ 0.5 | 1    | ≥ 2  | ≤ 0.06–8 | 0.12 | 8        | 64 | 0 | 36 |
| Piperacillin-tazobactam              | ≤ 32  | 64   | ≥ 128| ≤ 0.06–16 | 0.25 | 16       | 100 | 0 | 0 |
| Cefoxitin                            | ≤ 16  | 32   | ≥ 64 | 0.25–4 | 0.50 | 16       | 100 | 0 | 0 |
| Cefotetan                            | ≤ 16  | 32   | ≥ 64 | 0.25–128 | 4 | 128       | 50 | 7 | 43 |
| Imipenem                             | ≤ 4   | 8    | ≥ 16 | ≤ 0.06–4 | 0.25 | 4        | 100 | 0 | 0 |

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Table 1. Continued

| N of isolates and antimicrobial agents | Breakpoint (µg/mL) | MIC (µg/mL) | Susceptibility (%)* |
|---------------------------------------|-------------------|------------|---------------------|
|                                       | S     | I     | R     | Range | 50%   | 90%   | S  | I  | R   |
| Clindamycin                           | ≤ 2   | 4     | ≥ 8   | 0.06–128 | 0.25  | 128   | 50 | 7  | 43  |
| Moxifloxacin                          | ≤ 2   | 4     | ≥ 8   | 0.12–16 | 2     | 8     | 64 | 7  | 29  |
| Metronidazole                         | ≤ 8   | 16    | ≥ 32  | 0.5–8  | 2     | 2     | 100| 0  | 0   |
| Tetracycline                          | ≤ 4   | 8     | ≥ 16  | 0.25–64 | 32    | 64    | 14 | 0  | 86  |
| *Clostridioides difficile (15)         |       |       |       |        |       |       |     |     |     |
| Penicillin                            | ≤ 0.5 | 1     | ≥ 2   | ≤ 2–4  | 2     | 4     | 0  | 0  | 100 |
| Piperacillin-tazobactam              | ≤ 32  | 64    | ≥ 128 | 4–16   | 16    | 16    | 100| 0  | 0   |
| Cefoxitin                            | ≤ 16  | 32    | ≥ 64  | 128–>128 | 128  | >128  | 0  | 0  | 100 |
| Cefotetan                            | ≤ 16  | 32    | ≥ 64  | 16–64  | 32    | 64    | 20 | 40 | 40  |
| Imipenem                             | ≤ 4   | 8     | ≥ 16  | 4–64   | 16    | 32    | 7  | 93 |     |
| Clindamycin                          | ≤ 2   | 4     | ≥ 8   | 1–128  | 16    | >128  | 7  | 27 | 67  |
| Moxifloxacin                         | ≤ 2   | 4     | ≥ 8   | 1–32   | 16    | 32    | 47 | 0  | 53  |
| Metronidazole                        | ≤ 8   | 16    | ≥ 32  | 0.5–4  | 2     | 2     | 100| 0  | 0   |
| Tetracycline                         | ≤ 4   | 8     | ≥ 16  | 0.25–32| 0.5   | 32    | 60 | 13 | 27  |
| *Clostridium spp. (27)                |       |       |       |        |       |       |     |     |     |
| Penicillin                            | ≤ 0.5 | 1     | ≥ 2   | ≤ 2–4  | 2     | 4     | 0  | 0  | 100 |
| Piperacillin-tazobactam              | ≤ 32  | 64    | ≥ 128 | 4–16   | 16    | 16    | 100| 0  | 0   |
| Cefoxitin                            | ≤ 16  | 32    | ≥ 64  | 0.25–128 | 2    | 64    | 85 | 4  | 11  |
| Cefotetan                            | ≤ 16  | 32    | ≥ 64  | 4–16   | 1    | >128  | 78 | 4  | 19  |
| Imipenem                             | ≤ 4   | 8     | ≥ 16  | 2–64   | 1     | 4     | 96 | 4  | 0   |
| Clindamycin                          | ≤ 2   | 4     | ≥ 8   | ≤ 0.06–128 | 1    | >128  | 63 | 4  | 33  |
| Moxifloxacin                         | ≤ 2   | 4     | ≥ 8   | 1–128  | 1     | 32    | 74 | 7  | 19  |
| Metronidazole                        | ≤ 8   | 16    | ≥ 32  | 0.25–64 | 2     | 8     | 93 | 0  | 7   |
| Tetracycline                         | ≤ 4   | 8     | ≥ 16  | 0.12–64 | 16    | 64    | 26 | 11 | 63  |
| *Actinomyces odontolyticus (34)       |       |       |       |        |       |       |     |     |     |
| Penicillin                            | ≤ 0.5 | 1     | ≥ 2   | ≤ 0.06–8 | 0.5  | 8     | 53 | 18 | 29  |
| Piperacillin-tazobactam              | ≤ 32  | 64    | ≥ 128 | 0.5–64 | 4     | 32    | 91 | 9  | 0   |
| Cefoxitin                            | ≤ 16  | 32    | ≥ 64  | ≤ 0.06–32 | 1    | 16    | 97 | 3  | 0   |
| Cefotetan                            | ≤ 16  | 32    | ≥ 64  | 0.5–128 | 8    | 128   | 65 | 12 | 24  |
| Imipenem                             | ≤ 4   | 8     | ≥ 16  | ≤ 0.06–8 | 0.5  | 2     | 97 | 3  | 0   |
| Clindamycin                          | ≤ 2   | 4     | ≥ 8   | ≤ 0.06–128 | 0.5  | >128  | 62 | 0  | 38  |
| Moxifloxacin                         | ≤ 2   | 4     | ≥ 8   | 2–32   | 2     | 2     | 97 | 0  | 3   |
| Metronidazole                        | ≤ 8   | 16    | ≥ 32  | 8–128  | 32    | >128  | 6  | 29 | 65  |
| Tetracycline                         | ≤ 4   | 8     | ≥ 16  | 2–32   | 2     | 16    | 79 | 0  | 21  |
| *Actinomyces spp. (23)                |       |       |       |        |       |       |     |     |     |
| Penicillin                            | ≤ 0.5 | 1     | ≥ 2   | ≤ 0.06–0.5 | 0.12 | 0.12 | 100| 0  | 0   |
| Piperacillin-tazobactam              | ≤ 32  | 64    | ≥ 128 | ≤ 0.06–1 | 0.5  | 1    | 100| 0  | 0   |
| Cefoxitin                            | ≤ 16  | 32    | ≥ 64  | 0.12–1  | 0.25 | 1    | 100| 0  | 0   |
| Cefotetan                            | ≤ 16  | 32    | ≥ 64  | ≤ 0.06–4 | 0.5  | 4    | 100| 0  | 0   |
| Imipenem                             | ≤ 4   | 8     | ≥ 16  | ≤ 0.06–0.25 | ≤0.06 | 0.25 | 100| 0  | 0   |

(Continued to the next page)
| Bacterium                             | Breakpoint (µg/mL) | MIC (µg/mL) | Susceptibility (%)* |
|--------------------------------------|--------------------|-------------|---------------------|
|                                      | S                  | I           | R                   |
|                                      | Range              | 50%         | 90%                 | S     | I     | R     |
| **Clindamycin**                      | ≤ 2                | 4           | ≥ 8                 | ≤ 0.06–128 | 0.25 | > 128 | 78    | 0    | 22    |
| **Moxifloxacin**                     | ≤ 2                | 4           | ≥ 8                 | 0.5–2     | 1    | 2     | 100   | 0    | 0     |
| **Metronidazole**                    | ≤ 8                | 16          | ≥ 32                | 32–>128   | > 128| > 128 | 0     | 0    | 100   |
| **Tetracycline**                     | ≤ 4                | 8           | ≥ 16                | 0.5–64    | 1    | 32    | 78    | 0    | 22    |
| **Bifidobacterium spp. (18)**       |                    |             |                     |         |      |       |       |      |       |
| Penicillin                           | ≤ 0.5              | 1           | ≥ 2                 | ≤ 0.06–4  | 0.12 | 4     | 72    | 11   | 17    |
| Piperacillin-tazobactam              | ≤ 32               | 64          | ≥ 128               | ≤ 0.06–32 | 0.12 | 16    | 100   | 0    | 0     |
| Cefoxitin                            | ≤ 16               | 32          | ≥ 64                | ≤ 0.06–64 | 1    | 64    | 83    | 0    | 17    |
| Cefotetan                            | ≤ 16               | 32          | ≥ 64                | 0.25–>128 | 2    | > 128 | 72    | 0    | 28    |
| Imipenem                             | ≤ 4                | 8           | ≥ 16                | ≤ 0.06–1  | 0.12 | 0.5   | 100   | 0    | 0     |
| Clindamycin                          | ≤ 2                | 4           | ≥ 8                 | ≤ 0.06–128| 0.5  | > 128 | 72    | 0    | 28    |
| Moxifloxacin                         | ≤ 2                | 4           | ≥ 8                 | ≤ 0.06–16 | 1    | 4     | 89    | 6    | 6     |
| Metronidazole                        | ≤ 8                | 16          | ≥ 32                | 0.5–>128  | 8    | > 128 | 67    | 11   | 22    |
| Tetracycline                         | ≤ 4                | 8           | ≥ 16                | 2–128     | 2    | 16    | 83    | 6    | 11    |
| **Eggerthella lenta (38)**           |                    |             |                     |         |      |       |       |      |       |
| Penicillin                           | ≤ 0.5              | 1           | ≥ 2                 | 0.5–2     | 1    | 2     | 8     | 45   | 47    |
| Piperacillin-tazobactam              | ≤ 32               | 64          | ≥ 128               | 16–32     | 16   | 32    | 100   | 0    | 0     |
| Cefoxitin                            | ≤ 16               | 32          | ≥ 64                | 2–32      | 8    | 16    | 95    | 5    | 0     |
| Cefotetan                            | ≤ 16               | 32          | ≥ 64                | 32–>128   | 128  | > 128 | 0     | 5    | 95    |
| Imipenem                             | ≤ 4                | 8           | ≥ 16                | 0.5–0.5   | 0.5  | 1     | 100   | 0    | 0     |
| Clindamycin                          | ≤ 2                | 4           | ≥ 8                 | 0.12–0.5  | 0.5  | > 128 | 63    | 0    | 37    |
| Moxifloxacin                         | ≤ 2                | 4           | ≥ 8                 | 0.12–4    | 4    | 64    | 47    | 21   | 32    |
| Metronidazole                        | ≤ 8                | 16          | ≥ 32                | 0.5–1     | 1    | 1     | 100   | 0    | 0     |
| Tetracycline                         | ≤ 4                | 8           | ≥ 16                | 0.5–32    | 32   | 64    | 37    | 3    | 61    |
| **Lactobacillus spp. (36)*****       |                    |             |                     |         |      |       |       |      |       |
| Penicillin                           | ≤ 0.5              | 1           | ≥ 2                 | ≤ 0.06–>128| 0.5  | 2     | 56    | 22   | 22    |
| Piperacillin-tazobactam              | ≤ 32               | 64          | ≥ 128               | 0.5–>128  | 4    | 8     | 94    | 0    | 6     |
| Cefoxitin                            | ≤ 16               | 32          | ≥ 64                | 4–>128    | > 128| > 128 | 17    | 3    | 81    |
| Cefotetan                            | ≤ 16               | 32          | ≥ 64                | 8–>128    | > 128| > 128 | 3     | 0    | 97    |
| Imipenem                             | ≤ 4                | 8           | ≥ 16                | ≤ 0.06–16 | 0.25 | 8     | 86    | 11   | 3     |
| Clindamycin                          | ≤ 2                | 4           | ≥ 8                 | ≤ 0.06–1  | 0.12 | 0.5   | 100   | 0    | 0     |
| Moxifloxacin                         | ≤ 2                | 4           | ≥ 8                 | 0.25–4    | 1    | 2     | 94    | 6    | 0     |
| Metronidazole                        | ≤ 8                | 16          | ≥ 32                | 32–>128   | > 128| > 128 | 0     | 0    | 100   |
| Tetracycline                         | ≤ 4                | 8           | ≥ 16                | 0.5–>128  | 8    | 32    | 44    | 33   | 22    |
| **Other gram-positive bacilli (26)**††|                    |             |                     |         |      |       |       |      |       |
| Penicillin                           | ≤ 0.5              | 1           | ≥ 2                 | ≤ 0.06–4  | 0.12 | 0.25  | 96    | 0    | 4     |
| Piperacillin-tazobactam              | ≤ 32               | 64          | ≥ 128               | ≤ 0.06–2  | 0.12 | 2     | 100   | 0    | 0     |
| Cefoxitin                            | ≤ 16               | 32          | ≥ 64                | ≤ 0.06–16 | 1    | 4     | 100   | 0    | 0     |
| Cefotetan                            | ≤ 16               | 32          | ≥ 64                | ≤ 0.06–32 | 2    | 8     | 96    | 4    | 0     |
| Imipenem                             | ≤ 4                | 8           | ≥ 16                | ≤ 0.06–0.5| ≤ 0.06| 0.12  | 100   | 0    | 0     |

(Continued to the next page)
Table 1. Continued

| N of isolates and antimicrobial agents | Breakpoint (µg/mL) | MIC (µg/mL) | Susceptibility (%)* |
|---------------------------------------|------------------|-------------|---------------------|
|                                       | S    | I   | R   | Range | 50% | 90% | S | I | R |
| Clindamycin                           | ≤2   | 4   | ≥8  | 0.06–64 | 0.06 | 4   | 85 | 8 | 8 |
| Moxifloxacin                          | ≤2   | 4   | ≥8  | 0.06–4  | 0.25 | 1   | 96 | 4 | 0 |
| Metronidazole                         | ≤8   | 16  | ≥32 | 0.25–>128 | 8    | >128 | 60 | 0 | 40 |
| Tetracycline                          | ≤4   | 8   | ≥16 | 0.25–8  | 2    | 8   | 72 | 28 | 0 |

*Susceptibility was determined by breakpoint according to the CLSI M100 27th edition [19]; 1Bacteroides thetaiotaomicron (N=26), B. caccae (N=9), B. uniformis (N=7), B. vulgatus (N=7), B. ovatus (N=5); 2B. intestinalis (N=4), B. nordii (N=3), B. pygegenes (N=2), B. stercoris (N=2), B. salyersiae (N=2), B. cellulosolyticus (N=1); 3Parabacteroides goldsteinii (N=5), P. johnsonii (N=2), P. merdae (N=2), P. faecis (N=1); 4Prevotella buccae (N=15), P. bivia (N=10), P. nigrescens (N=3), P. buccalis (N=1), P. disiens (N=1), P. intermedia (N=1), P. melaninogenica (N=1), P. oralis (N=1); 5 Fusobacterium varium (N=14), F. mortiferum (N=2), F. ulcerans (N=2), F. nucleatum (N=1); 6 Dialister pneumoniae (N=2), Leptotrichia trevisanii (N=2), L. buccalis (N=1), Alistipes finegoldii (N=1), A. ondorokii (N=1), Bilophila sp. (N=1), Megamonas sp. (N=1), Sutterella wadsworthensis (N=1); 7Veillonella parvula (N=9), V. atypica (N=1), V. dispar (N=1); 8Peptonophilus anaerobius (N=3), P. asaccharolyticus (N=2), P. gorbachi (N=2), P. harei (N=1), Anaerococcus vaginalis (N=2), A. mordochii (N=1), A. prevotii (N=1), Ruminococcus gravis (N=2); 9Clostridium bifermentans (N=3), C. hathewayi (N=3), C. innocuum (N=3), C. paraputrificum (N=3), C. perfringens (N=3), C. butyricum (N=2), C. ramosum (N=2), C. sordelli (N=2), C. tertium (N=2), C. cacodyes (N=1), C. scindens (N=1), C. sporogenes (N=1), C. bolettae (N=1); 10Actinomyces oris (N=7), A. turicensis (N=7), A. neui (N=4), A. viscosus (N=2), A. europaeus (N=1), A. meyeri (N=1), A. naesiundii (N=1); 11Bifidobacterium dentium (N=5), B. longum (N=5), B. breve (N=4), B. bifidum (N=2), B. pseudocatenulatum (N=1), B. thermophilum (N=1); 12Lactobacillus paracasei (N=5), L. rhamnosus (N=5), L. sakei (N=5), L. salivarius (N=4), L. fermentum (N=3), L. mucosae (N=3), L. crispatus (N=2), L. gasseri (N=2), L. plantarum (N=2), L. reuteri (N=2), L. curvatus (N=1), L. helribisinos (N=1), L. sporogenes (N=1); 13Propionibacterium acnes (N=7), A. rimae (N=2), Propionibacterium acnes (N=5), P. avidum (N=1), P. liphophillum (N=1), Actinobacter fragilis (N=2), Alloscardovia omniconclus (N=2), Bulleidia extructa (N=2), Collinsella aerofaciens (N=2), Flavonifractor plautii (N=1), Slackia exigua (N=1).

Abbreviations: S, susceptible; I, intermediate; R, resistant; MIC, minimum inhibitory concentration.

Anaerobic resistance trends in Korea

Byun JH, et al.

Anaerobic gram-positive isolates

A total of 74 anaerobic GPC, including 31 Finegoldia magna and 29 Parvimonas micra, exhibited various resistance rates to moxifloxacin (6–48%), clindamycin (3–43%), and tetracycline (6–86%). Overall, F. magna isolates were more susceptible than other GPC isolates, with a resistance rate <6% to all antimicrobials tested (Table 1). The resistance rate of the other GPC isolates to penicillin was 36%, with all species identified as Peptoniphilus.

C. difficile showed high resistance to penicillin (100%), cefoxitin (100%), imipenem (93%), and moxifloxacin (53%). All non-odontolyticus Actinomyces and Lactobacillus isolates and 65% of Actinomyces odontolyticus isolates were resistant to metronidazole. All non-odontolyticus Actinomyces isolates were susceptible to the other antimicrobial agents tested, except for clindamycin (22% resistance) and tetracycline (22% resistance). E. lentum demonstrated high resistance rates to penicillin (47%), cefotetan (95%), tetracycline (61%), and moxifloxacin (32%). Other GPB, such as Actinomignum, Alloscardovia, Bulleidia, Collinsella, Flavonifractor, and Slackia, were generally susceptible to all agents tested, except for metronidazole.

DISCUSSION

The Bacteroides fragilis group of anaerobic gram-negative iso-
lates (including Parabacteroides spp.) are the most clinically significant anaerobes because they are commonly isolated from clinical specimens and show greater virulence and resistance than most other anaerobes [10]. The resistance of B. fragilis isolates to cefotetan remained low for several years: 14% in 1997–2004 [8], 14% in 2007–2008 [7], 13% in 2009–2012 [9], and 12% in 2014–2016. The resistance of B. fragilis isolates to moxifloxacin has steadily increased over the past 11 years, from 11% in 2007–2008 to 20% in 2014–2016. The current values are similar to those observed in 2010–2012 in the USA (19.1%) [21]. The resistance to moxifloxacin among non-fragilis Bacteroides group species has not increased; the rates have ranged from 18% in 2007–2008 to 16% in 2014–2016 [7]. This may reflect the fact that the B. fragilis group includes former members of the group previously reclassified as Parabacteroides spp. [7]. Parabacteroides spp. had a higher resistance rate to clindamycin and a lower resistance rate to moxifloxacin compared with isolates in the USA (50% and 44%, respectively) [21].

We observed that non-fragilis Bacteroides Group II had higher resistance rates to meropenem than imipenem, while non-fragilis Bacteroides Group I demonstrated the opposite pattern. Such patterns have been previously reported by Sóki et al. [22]; however, they did not include the carbapenem resistance patterns of non-fragilis Bacteroides Group II.

Prevotella spp. were highly susceptible to most antimicrobials except penicillin and clindamycin. The resistance rates to clindamycin remained high, at 45%, for Prevotella spp., compared with 50% in 2007–2008 [7]. Only one Prevotella spp. isolate was resistant to metronidazole. This represents an even lower rate of resistance than that reported in Greece (8%) [23]. The Veillonella resistance rate to metronidazole was 27%, higher than that reported in the USA (11%) [4].

The anaerobic GPC isolates exhibited various rates of resistance to penicillin, clindamycin, and metronidazole [2]. However, the resistance rate of GPC to clindamycin, moxifloxacin, and tetracycline varied across species. The resistance of C. difficile to imipenem has rapidly increased over the past years, from 8% in 2007–2008 to 93% in 2014–2016 [7]. There is a general assumption that resistance varies with ribotype; Lee et al. [24] showed that ribotypes 017 and 018 have high MICs for moxifloxacin and imipenem, compared with ribotype 001. Metronidazole-resistant isolates were common among Actinomyces and Lactobacillus spp. A study in Argentina showed that all Actinomyces spp. were susceptible to penicillin, and 21.2% were resistant to clindamycin [25]. E. lenta has been commonly associated with gastrointestinal infections; its overall mortality is significant, ranging from 36% to 48% [26, 27]. The E. lenta resistance rates we observed were much higher than those in Australia (0% for penicillin and 12% for moxifloxacin) [26].

The limitations of this study were the small number of renamed and reclassified bacteria and bacterial isolates collected. Further, it was a single-center, retrospective study.

In conclusion, piperacillin-tazobactam, cefoxitin, and carbapenems were β-lactam agents highly active against most of the anaerobic bacteria we tested. However, recently renamed non-fragilis Bacteroides group isolates showed resistance to meropenem (14%). These data suggest the importance of ongoing surveillance to provide clinically relevant information to clinicians for the empirical management of infections caused by anaerobic organisms. Continuous monitoring is necessary to detect changes in antimicrobial resistance patterns.

Authors’ Disclosures of Potential Conflicts of Interest
No potential conflicts of interest relevant to this article were reported.

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REFERENCES
1. Schuetz AN. Antimicrobial resistance and susceptibility testing of anaerobic bacteria. Clin Infect Dis 2014;59:698-705.
2. Hecht DW. Anaerobes: antibiotic resistance, clinical significance, and the role of susceptibility testing. Anaerobe 2006;12:115-21.
3. Lee Y, Park YJ, Kim MN, Uh Y, Kim MS, Lee K. Multicenter study of antimicrobial susceptibility of anaerobic bacteria in Korea in 2012. Ann Lab Med 2015;35:479-86.
4. Hastey CJ, Boyd H, Schuetz AN, Anderson K, Citron DM, Dzink-Fox J, et al. Changes in the antibiotic susceptibility of anaerobic bacteria from 2007–2009 to 2010–2012 based on the CLSI methodology. Anaerobe 2016;42:27-30.
5. CLSI. Methods for antimicrobial susceptibility testing of anaerobic bacteria. Approved standard. 8th ed. CLSI M11-A8. Wayne, PA: Clinical and Laboratory Standards Institute. 2012.
6. Lee K, Shin HB, Chong Y. Antimicrobial resistance patterns of Bacteroides fragilis group organisms in Korea. Yonsei Med J 1998;39:578-86.
7. Lee Y, Park Y, Kim MS, Yong D, Jeong SH, Lee K, et al. Antimicrobial susceptibility patterns for recent clinical isolates of anaerobic bacteria in South Korea. Antimicrob Agents Chemother 2010;54:3993-7.
8. Roh KH, Kim S, Kim CK, Yum JH, Kim MS, Yong D, et al. Resistance
trends of Bacteroides fragilis group over an 8-year period, 1997-2004, in Korea. Korean J Lab Med 2009;29:293-8.
9. Yim J, Lee Y, Kim M, Seo YH, Kim WH, Yong D, et al. Antimicrobial susceptibility testing of clinical isolates of Bacteroides fragilis group organisms recovered from 2009 to 2012 in a Korean hospital. Ann Lab Med 2015;35:94-9.
10. Wexler HM. Bacteroides: the good, the bad, and the nitty-gritty. Clin Microbiol Rev 2007;20:593-621.
11. Sóki J, Hedberg M, Patrick S, Bálint B, Herczeg R, Nagy I, et al. Emergence and evolution of an international cluster of MDR Bacteroides fragilis isolates. J Antimicrob Chemother 2016;71:2441-8.
12. Merchan C, Parajuli S, Siegfried J, Scipione MR, Dubrovskaya Y, Rahimian J, et al. Multidrug-resistant Bacteroides fragilis bacteremia in a US resident: an emerging challenge. Case Rep Infect Dis 2016;2016:3607125.
13. Sakamoto M and Benno Y. Reclassification of Bacteroides distasonis, Bacteroides goldsteinii and Bacteroides merdae as Parabacteroides distasonis gen. nov., comb. nov., Parabacteroides goldsteinii comb. nov. and Parabacteroides merdae comb. nov. Int J Syst Evol Microbiol 2006;56:1599-605.
14. Huys G, Vancanneyt M, D’Haene K, Falsen E, Vandamme P. Alloscardovia omnicolens gen. nov., sp. nov., from human clinical samples. Int J Syst Evol Microbiol 2007;57:1442-6.
15. Downes J, Olsvik B, Hiom SJ, Spratt DA, Cheeseman SL, Olsen I, et al. Bulleidia extructa gen. nov., sp. nov., isolated from the oral cavity. Int J Syst Evol Microbiol 2000;50:979-83.
16. Tee W, Midolo P, Janssen PH, Kerr T, Dyall-Smith ML. Bacteremia due to Leptotrichia trevisanii sp. nov. Eur J Clin Microbiol Infect Dis 2001;20:765-9.
17. Rautio M, Errola E, Väisänen-Tunkelrott ML, Molitoris D, Lawson P, Collins MD, et al. Reclassification of Bacteroides putredinis (Weinberg et al., 1937) in a new genus Alistipes gen. nov., as Alistipes putredinis comb. nov., and description of Alistipes finegildii sp. nov., from human sources. Syst Appl Microbiol 2003;26:182-8.
18. Song Y, Könönen E, Rautio M, Liu C, Bryk A, Errola E, et al. Alistipes onderdonkii sp. nov. and Alistipes shahii sp. nov., of human origin. Int J Syst Evol Microbiol 2006;56:1985-90.
19. CLSI. Methods for antimicrobial susceptibility testing of anaerobic bacteria. Approved standard. 27th ed. CLSI M100. Wayne, PA: Clinical and Laboratory Standards Institute. 2017.
20. Yong D, Lee Y, Jeong SH, Lee K, Chong Y. Evaluation of double-disk potentiation and disk potentiation tests using dipicolinic acid for detection of metallo-β-lactamase-producing Pseudomonas spp. and Acinetobacter spp. J Clin Microbiol 2012;50:3227-32.
21. Snydman DR, Jacobus NV, McDermott LA, Goldstein EJ, Harrell L, Jenkins SG, et al. Trends in antimicrobial resistance among Bacteroides species and Parabacteroides species in the United States from 2010-2012 with comparison to 2008-2009. Anaerobe 2017;43:21-6.
22. Sóki J, Edwards R, Hedberg M, Fang H, Nagy E, Nord CE, et al. Examination of cfiA-mediated carbapenem resistance in Bacteroides fragilis strains from a European antibiotic susceptibility survey. Int J Antimicrob Agents 2006;28:497-502.
23. Papaparaskevas J, Pantazatou A, Katsandri A, Houhoula DP, Legakis NJ, Tsakris A, et al. Moxifloxacin resistance is prevalent among Bacteroides and Prevotella species in Greece. J Antimicrob Chemother 2008;62:137-41.
24. Lee JH, Lee Y, Lee K, Riley TV, Kim H. The changes of PCR ribotype and antimicrobial resistance of Clostridium difficile in a tertiary care hospital over 10 years. J Med Microbiol 2014;63:819-23.
25. Barberis C, Budia M, Palombarani S, Rodriguez CH, Ramírez MS, Arias B, et al. Antimicrobial susceptibility of clinical isolates of Actinomyces and related genera reveals an unusual clindamycin resistance among Actinomyces urogenitalis strains. J Glob Antimicrob Resist 2017;8:115-20.
26. Lee MR, Huang YT, Liao CH, Chuang TY, Wang WJ, Lee SW, et al. Clinical and microbiological characteristics of bacteremia caused by Eggerthella, Paraeggerthella and Eubacterium species at a university hospital in Taiwan, 2001-2010. J Clin Microbiol 2012;50:2053-5.
27. Venugopal AA, Szpunar S, Johnson LB. Risk and prognostic factors among patients with bacteremia due to Eggerthella lenta. Anaerobe 2012;18:475-8.