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In Vitro Activities of Moxifloxacin against 900 Aerobic and Anaerobic Surgical Isolates from Patients with Intra-Abdominal and Diabetic Foot Infections

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The in vitro activities of moxifloxacin, ciprofloxacin, levofloxacin, gatifloxacin, imipenem, piperacillin-tazobactam, clindamycin, and metronidazole against 900 surgical isolates were determined using NCCLS testing methods. Moxifloxacin exhibited good to excellent antimicrobial activity against most aerobic (90.8%) and anaerobic (97.1%) microorganisms, suggesting that it may be effective for the treatment of polymicrobial surgical infections.

Infections of the abdominal-pelvic vaults and diabetic limbs involve a mixed microbial flora, often characterized by a high level of antimicrobial resistance (5–7). In addition to appropriate antimicrobial spectrum, the ideal antimicrobial agent must also have extensive tissue distribution, as many surgical infections occur in sites where there is significant disruption of tissue plains and vascular supply (7, 17, 22). Since the introduction of ciprofloxacin in the late 1980s, the fluoroquinolones have been viewed as potent antimicrobials for the treatment of serious gram-negative infections. Newer quinolones have improved in vitro activity against anaerobes, with trovafloxacin, moxifloxacin, and gatifloxacin having more potent activities than levofloxacin and ciprofloxacin (1, 3). Unfortunately, safety and toxicity concerns have limited the potential therapeutic usefulness of many of these agents (11, 14, 15, 21). The present study was undertaken to investigate the in vitro activity of moxifloxacin against aerobic and anaerobic clinical isolates recently obtained from surgical patients with diabetic foot and intra-abdominal infections.

Nine hundred sequential, nonduplicated clinical isolates (350 aerobic and 550 anaerobic strains) were collected over a 3-year period (1999 to 2002) from patients with intra-abdominal and diabetic foot infections in a tertiary care medical center in Milwaukee, Wis. (three surgical services: vascular surgery, trauma and critical care, and pancreatobiliary surgery). NCCLS-recommended reference broth and agar dilution methods were used for aerobic and anaerobic susceptibility testing, respectively (18, 19). Microbroth and agar dilution plates were prepared on the day of testing and incubated at 35°C for 24 h (aerobes) and 48 h (anaerobes), respectively. Gram-positive and gram-negative aerobic-facultative isolates were tested in Mueller-Hinton broth. Anaerobic strains were tested within an anaerobic chamber on brucella blood agar plates supplemented with 5 μg of hemin, 1 μg of vitamin K_1 per ml, and 5% lysed sheep blood. The agar dilution plates were inoculated (10^5 CFU/spot) using a 32-prong Steers replicator device. Antimicrobial standard powders (ciprofloxacin and moxifloxacin [Bayer Corp., West Haven, Conn.], gatifloxacin [Bristol-Myers Squibb, Princeton, N.J.], levofloxacin [Ortho-McNeil Pharmaceuticals, Raritan, N.J.], imipenem [Merck & Co., Inc., Rahway, N.J.], piperacillin-tazobactam [Wyeth-Ayerst, St. Davids, Pa.], clindamycin [Pharmacia-Upjohn, Kalamazoo, Mich.], and metronidazole [SCS, Chicago, Ill.]) were reconstituted according to the manufacturers' instructions, serially diluted, and added to appropriate media for testing. Control strains included *Staphylococcus aureus* ATCC 29213, *Enterococcus faecalis* ATCC 29212, *Escherichia coli* ATCC 25922, *Bacteroides fragilis* ATCC 25285, *Bacteroides thetaiotaomicron* ATCC 29741, and *Eubacterium lentum* ATCC 4305.

The susceptibilities of the aerobic isolates, listed by species, are shown in Table 1. The results are expressed as the MICs at which 50 and 90% of strains were inhibited (MIC_{50} and MIC_{90}, respectively) and the ranges for all strains. While moxifloxacin, gatifloxacin, and imipenem demonstrated good activity against methicillin-susceptible *S. aureus*, *E. faecalis*, and *Streptococcus* spp., all agents tested failed to provide reliable in vitro activity (based on MIC_{90}s) against methicillin-resistant *S. aureus*, *Staphylococcus epidermidis*, and *Enterococcus faecium*. All four fluoroquinolones tested demonstrated excellent activity against gram-negative aerobic isolates. Imipenem also demonstrated excellent activity against all gram-negative aerobic isolates ($MIC_{90} \leq 0.5$ mg/liter). Piperacillin-tazobactam was active against *E. coli*, *Klebsiella* spp., *Proteus mirabilis*, and *Morganella morganii* ($MIC_{90} \leq 8.0$ mg/liter). However, for *Citrobacter* spp. and *Enterobacter* spp., the percent susceptibility to piperacillin-tazobactam was highly variable (range, 70 to 83.3%). Overall, 90.8% of aerobic gram-positive and gram-negative surgical isolates were susceptible to moxifloxacin.

Among the 550 gram-positive and gram-negative anaerobes tested, *Bacteroides* was the most common genus ($n = 310$),

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TABLE 1. Activities of moxifloxacin and other agents against 350 gram-positive and gram-negative aerobic-facultative isolates from surgical patients

Organism (no. of isolates) and agent	MIC (mg/liter)[a]			% Susceptibility (all isolates)
	Range	50%	90%	
Methicillin-susceptible *S. aureus* (40)				
Ciprofloxacin	0.5–2.0	0.5	2.0	80
Moxifloxacin	≤0.03–0.25	0.12	0.25	95
Gatifloxacin	≤0.06–0.5	0.25	0.5	95
Levofloxacin	0.25–1.0	0.5	1.0	85
Piperacillin-tazobactam	≤0.12–16.0	1.0	4.0	97.5
Imipenem	0.06–0.25	0.06	0.25	97.5
Methicillin-resistant *S. aureus* (20)				
Ciprofloxacin	0.5–>8.0	1.0	>8.0	65
Moxifloxacin	0.25–>8.0	0.25	8.0	70
Gatifloxacin	0.5–>8.0	1.0	>8.0	60
Levofloxacin	0.5–>8.0	2.0	>8.0	60
Piperacillin-tazobactam	2–>128.0	8.0	>128.0	65
Imipenem	0.5–>16.0	4.0	>16.0	65
Methicillin-resistant *S. epidermidis* (20)				
Ciprofloxacin	0.25–>8.0	4.0	>8.0	45
Moxifloxacin	0.12–>8.0	1.0	>8.0	55
Gatifloxacin	0.12–>8.0	4.0	>8.0	45
Levofloxacin	0.5–>8.0	8.0	>8.0	35
Piperacillin-tazobactam	0.5–>128.0	4.0	>128.0	65
Imipenem	0.25–>16.0	2.0	>16.0	65
E. faecium (20)				
Ciprofloxacin	1.0–>8.0	4.0	>8.0	35
Moxifloxacin	0.12–>8.0	2.0	8.0	40
Gatifloxacin	0.25–>8.0	4.0	>8.0	30
Levofloxacin	0.5–>8.0	8.0	>8.0	25
Piperacillin-tazobactam	2.0–>128.0	64.0	>128.0	30
Imipenem	0.5–>16.0	8.0	>16.0	30
E. faecalis (20)				
Ciprofloxacin	0.12–8.0	1.0	>8.0	70
Moxifloxacin	0.12–>8.0	0.5	1.0	90
Gatifloxacin	0.25–>8.0	1.0	2.0	80
Levofloxacin	1.0–>8.0	2.0	>8.0	65
Piperacillin-tazobactam	2.0–64.0	2.0	16.0	90
Imipenem	0.5–>16.0	2.0	8.0	85
Streptococcus spp. (30)[b]				
Ciprofloxacin	0.12–>8.0	0.5	>8.0	85.7
Moxifloxacin	0.06–0.5	0.25	0.5	100
Gatifloxacin	0.12–0.5	0.5	0.5	100
Levofloxacin	0.25–2.0	0.5	2.0	100
Piperacillin-tazobactam	0.12–8.0	0.12	8.0	100
Imipenem	0.03–0.25	0.12	0.25	100
Citrobacter freundii (10)				
Ciprofloxacin	≤0.03–4.0	0.06	0.5	90
Moxifloxacin	0.03–4.0	0.25	1.0	90
Gatifloxacin	0.06–4.0	0.50	1.0	90
Levofloxacin	<0.03–2.0	0.03	0.5	100
Piperacillin-tazobactam	0.12–>128.0	4.0	>128.0	80
Imipenem	<0.03–8.0	0.12	0.5	100
Enterobacter aerogenes (10)				
Ciprofloxacin	≤0.03–4.0	0.06	0.25	90
Moxifloxacin	≤0.03–2.0	0.12	0.50	100
Gatifloxacin	≤0.03–1.0	0.06	0.50	100
Levofloxacin	0.06–1.0	0.12	0.25	100
Piperacillin-tazobactam	0.5–>128.0	4.0	>128.0	80
Imipenem	≤0.03–1.0	0.12	0.25	100
Enterobacter cloacae (10)				
Ciprofloxacin	≤0.03–0.5	0.06	0.25	100
Moxifloxacin	0.03–1.0	0.25	0.5	100
Gatifloxacin	0.03–1.0	0.05	1.0	100
Levofloxacin	0.06–0.5	0.12	0.5	100
Piperacillin-tazobactam	1.0–>128.0	4.0	128.0	70
Imipenem	≤0.03–2.0	0.12	0.25	100
E. coli (100)				
Ciprofloxacin	≤0.03–0.12	≤0.03	0.03	100
Moxifloxacin	≤0.03–0.25	0.03	0.06	100
Gatifloxacin	≤0.03–0.5	0.06	0.12	100
Levofloxacin	≤0.03–0.12	0.03	0.03	100
Piperacillin-tazobactam	0.12–>128.0	0.5	4.0	90
Imipenem	≤0.03–0.5	0.12	0.25	100
Klebsiella oxytoca (10)				
Ciprofloxacin	≤0.03–0.12	0.03	0.12	100
Moxifloxacin	≤0.03–0.25	0.12	0.25	100
Gatifloxacin	≤0.06–0.5	0.25	0.50	100
Levofloxacin	≤0.03–0.12	0.03	0.12	100
Piperacillin-tazobactam	0.25–128.0	0.5	4.0	90
Imipenem	≤0.03–1.0	0.25	0.50	100
Klebsiella pneumoniae (40)				
Ciprofloxacin	≤0.03–1.0	0.06	0.12	100
Moxifloxacin	0.06–2.0	0.25	1.0	100
Gatifloxacin	0.06–2.0	0.5	2.0	100
Levofloxacin	≤0.03–1.0	0.06	0.25	100
Piperacillin-tazobactam	0.12–64.0	1.0	8.0	90
Imipenem	≤0.03–1.0	0.12	0.5	100
M. morganii (10)				
Ciprofloxacin	≤0.06–0.5	0.06	0.25	100
Moxifloxacin	0.25–1.0	0.25	0.5	100
Gatifloxacin	0.12–4.0	0.50	1.0	90
Levofloxacin	0.03–0.5	0.06	0.5	100
Piperacillin-tazobactam	0.25–16.0	1.0	8.0	100
Imipenem	≤0.06–2.0	0.12	0.5	100
P. mirabilis (10)				
Ciprofloxacin	0.03–0.5	0.06	0.12	100
Moxifloxacin	0.12–1.0	0.5	1.0	100
Gatifloxacin	0.25–2.0	0.5	1.0	100
Levofloxacin	0.03–0.5	0.06	0.12	100
Piperacillin-tazobactam	0.5–128.0	0.5	2.0	90
Imipenem	≤0.03–0.5	0.12	0.25	100

[a] The following MICs were used as susceptibility breakpoints as recommended by the NCCLS (18): ciprofloxacin, ≤1 mg/liter; moxifloxacin, ≤2 mg/liter (*Staphylococcus* spp.) and ≤1 mg/liter (*Streptococcus* spp.) (note: no NCCLS breakpoints have been established for moxifloxacin against *Enterobacteriaceae*); gatifloxacin, ≤2 mg/liter (*Staphylococcus* spp.) and ≤1 mg/liter (*Streptococcus* spp.); levofloxacin, ≤2 mg/liter; piperacillin-tazobactam, ≤32 mg/liter (*Enterobacteriaceae*) and ≤8 mg/liter (*Staphylococcus* spp.); and imipenem, ≤4 mg/liter.

[b] *S. pyogenes* (10), *S. agalactiae* (10), *S. viridans* (10).

TABLE 2. Activities of moxifloxacin and other agents against 550 gram-positive and gram-negative anaerobic isolates from surgical patients

Organism (no. of isolates) and agent	MIC (mg/liter)[a]			% Susceptibility (all isolates)
	Range	50%	90%	
Actinomyces spp. (10)[b]				
Clindamycin	≤0.06–32	0.25	0.5	90
Imipenem	≤0.03–0.5	0.12	0.25	100
Moxifloxacin	0.25–4.0	1.0	2.0	100
Metronidazole	2.0–16.0	16.0	16.0	40
Piperacillin-tazobactam	<0.12–8.0	0.5	4.0	100
B. distasonis (40)				
Clindamycin	0.03–>32.0	0.12	4.0	80
Imipenem	0.12–0.5	0.25	0.5	100
Moxifloxacin	0.12–4.0	0.5	2.0	100
Metronidazole	0.06–1.0	0.5	1.0	100
Piperacillin-tazobactam	0.5–>128.0	8.0	32.0	85
B. fragilis (130)				
Clindamycin	0.25–>32.0	2.0	4.0	84.6
Imipenem	0.03–>8.0	0.25	2.0	95.3
Moxifloxacin	0.12–>8.0	0.5	1.0	96.9
Metronidazole	0.12–2.0	0.5	1.0	100
Piperacillin-tazobactam	≤0.06–128	2.0	8.0	93.8
B. ovatus (30)				
Clindamycin	1.0–>32	2.0	>32.0	80
Imipenem	0.12–1.0	0.5	1.0	100
Moxifloxacin	0.5–>8.0	2.0	2.0	93.3
Metronidazole	0.12–8.0	2.0	4.0	100
Piperacillin-tazobactam	0.06–16.0	4.0	16.0	100
B. thetaiotaomicron (40)				
Clindamycin	0.25–>32	4.0	>32	77.5
Imipenem	0.06–2.0	0.12	0.5	100
Moxifloxacin	1.0–>8.0	2.0	2.0	95
Metronidazole	0.25–4.0	1.0	2.0	100
Piperacillin-tazobactam	1.0–64.0	16.0	32.0	85
Bacteroides uniformis (20)				
Clindamycin	0.5–>32.0	4.0	16.0	45
Imipenem	0.06–>8.0	0.5	2.0	95
Moxifloxacin	0.25–>8.0	0.5	4.0	90
Metronidazole	0.12–2.0	0.5	1.0	100
Piperacillin-tazobactam	1.0–128.0	16.0	64.0	85
B. vulgatus (30)				
Clindamycin	0.03–>32.0	0.5	2.0	76.6
Imipenem	0.12–1.0	0.5	1.0	100
Moxifloxacin	0.25–>8.0	0.5	2.0	93.3
Metronidazole	0.25–4.0	1.0	2.0	100
Piperacillin-tazobactam	2.0–128.0	16.0	64.0	83.3
Bacteroides spp. (20)[c]				
Clindamycin	≤0.03–>32.0	2.0	>32.0	70
Imipenem	0.06–8.0	0.25	1.0	90
Moxifloxacin	0.25–>8.0	1.0	4.0	90
Metronidazole	0.06–2.0	1.0	2.0	100
Piperacillin-tazobactam	0.12–>128.0	2.0	16.0	95
C. perfringens (35)				
Clindamycin	0.03–>32.0	2.0	8.0	85.7
Imipenem	0.03–0.50	0.25	0.25	100
Moxifloxacin	0.25–4.0	1.0	2.0	100
Metronidazole	0.25–4.0	2.0	4.0	100
Piperacillin-tazobactam	0.06–0.5	0.12	0.25	100
Clostridium spp. (40)[d]				
Clindamycin	0.03–16.0	2.0	16.0	78.3
Imipenem	0.06–8.0	0.5	2.0	94.8
Moxifloxacin	0.25–4.0	0.5	1.0	100
Metronidazole	0.12–4.0	2.0	4.0	100
Piperacillin-tazobactam	≤0.06–32.0	4.0	32.0	89.1
E. lentum (20)				
Clindamycin	0.12–8.0	0.25	2.0	90
Imipenem	0.03–2.0	0.12	0.5	100
Moxifloxacin	0.03–1.0	0.25	0.5	100
Metronidazole	0.06–4.0	0.5	4.0	100
Piperacillin-tazobactam	0.25–32.0	1.0	8.0	95
F. mortiferum (10)				
Clindamycin	0.03–0.5	0.12	0.5	100
Imipenem	0.03–2.0	0.25	0.5	100
Moxifloxacin	0.5–2.0	0.5	1.0	100
Metronidazole	≤0.03–0.5	0.06	0.25	100
Piperacillin-tazobactam	0.12–2.0	0.5	2.0	100
F. nucleatum (10)				
Clindamycin	0.06–0.5	0.12	0.25	100
Imipenem	≤0.03–0.12	0.03	0.12	100
Moxifloxacin	0.25–1.0	0.25	0.5	100
Metronidazole	≤0.03–0.25	0.25	0.25	100
Piperacillin-tazobactam	≤0.06–1.0	0.06	0.25	100
Fusobacterium spp. (10)[e]				
Clindamycin	0.06–>32.0	2.0	32.0	70
Imipenem	≤0.03–2.0	0.50	2.0	100
Moxifloxacin	0.12–>8.0	1.0	8.0	80
Metronidazole	≤0.03–2.0	0.25	1.0	100
Piperacillin-tazobactam	0.12–32.0	0.5	8.0	90
Peptostreptococcus anaerobius (20)				
Clindamycin	0.06–16.0	0.25	2.0	90
Imipenem	0.03–0.5	0.06	0.12	100
Moxifloxacin	0.06–2.0	0.5	1.0	100
Metronidazole	0.5–8.0	2.0	4.0	100
Piperacillin-tazobactam	0.03–8.0	0.06	0.5	100
P. magnus (25)				
Clindamycin	0.06–8.0	0.25	4.0	84
Imipenem	≤0.03–0.5	0.12	0.12	100
Moxifloxacin	0.06–1.0	0.25	1.0	100
Metronidazole	0.25–2.0	2.0	2.0	100
Piperacillin-tazobactam	0.12–8.0	0.12	0.5	100
P. micros (20)				
Clindamycin	0.06–2.0	0.12	0.5	100
Imipenem	≤0.03–0.25	0.06	0.12	100
Moxifloxacin	0.03–1.0	0.12	0.5	100
Metronidazole	0.12–2.0	0.5	1.0	100
Piperacillin-tazobactam	0.06–2.0	0.12	0.25	100

Continued on following page

TABLE 2—*Continued*

Organism (no. of isolates) and agent	MIC (mg/liter)[a]			% Susceptibility (all isolates)
	Range	50%	90%	
Porphyromonas spp. (10)[f]				
Clindamycin	≤0.03–1.0	0.06	0.12	100
Imipenem	≤0.03–0.5	0.12	0.25	100
Moxifloxacin	0.06–2.0	1.0	1.0	100
Metronidazole	0.06–8.0	1.0	4.0	100
Piperacillin-tazobactam	0.12–4.0	0.12	0.25	100
Prevotella spp. (30)[g]				
Clindamycin	≤0.03–0.12	0.03	0.03	100
Imipenem	≤0.03–0.25	0.06	0.25	100
Moxifloxacin	0.25–2.0	1.0	2.0	100
Metronidazole	0.12–8.0	0.5	4.0	100
Piperacillin-tazobactam	0.06–2.0	0.12	0.25	100

[a] The following MICs were used as susceptibility breakpoints as recommended by the NCCLS (35): clindamycin, ≤2 mg/liter; imipenem, ≤4 mg/liter; moxifloxacin, ≤4 mg/liter (note: FDA breakpoint; no approved NCCLS breakpoints); metronidazole, ≤8 mg/liter; and piperacillin-tazobactam, ≤16 mg/liter.
[b] *A. viscosus* (4), *A. odontolyticus* (4), *A. naeslundii* (2).
[c] *B. eggerthii* (8), *B. merdae* (7), *B. splanchnicus* (5).
[d] *C. bifermentans* (2), *C. butyricum* (1), *C. cadaveris* (3), *C. difficile* (4), *C. hastiforme* (1), *C. histolyticum* (2), *C. innocuum* (7), *C. ramosum* (7), *C. sporogenes* (1), *C. subterminale* (6), *C. tertium* (2), *C. tyrobutyricum* (1).
[e] *F. varium* (2), *F. necrophorum* (7), *F. russii* (1).
[f] *P. asaccharolytica* (5), *P. gingivalis* (5).
[g] *P. buccae* (5), *P. denticola* (5), *P. intermedia* (5), *P. disiens* (5), *P. bivia* (5), *P. melaninogenicus* (5).

comprising 56.3% of the total number of isolates (Table 2), followed by *Clostridium* spp. (n = 72; 13%) and *Peptostreptococcus* spp. (n = 65; 12%). Against *B. fragilis*, moxifloxacin exhibited excellent in vitro activity, based on an MIC_{90} of 1 mg/liter (Table 2). Comparing the percent susceptibilities for *B. fragilis*, metronidazole, imipenem, and piperacillin-tazobactam demonstrated similar in vitro efficacies, while less than 85% of *B. fragilis* isolates were sensitive to clindamycin. The percent susceptibility of *B. fragilis* group isolates (*B. thetaiotaomicron*, *B. ovatus*, *B. vulgatus*, and *B. distasonis*) to moxifloxacin based on a proposed breakpoint (4 mg/liter) was similar to the values reported for imipenem, metronidazole, and piperacillin-tazobactam. In general, clindamycin activity against *B. fragilis* and non-*fragilis* strains was poor compared to the other test compounds. Moxifloxacin demonstrated excellent activity against *Clostridium perfringens* (MIC_{90} = 2 mg/liter) and other clostridial isolates (MIC_{90} = 1 mg/liter). Against *C. perfringens*, imipenem and piperacillin-tazobactam demonstrated the most potent in vitro activity (MIC_{90} = 0.25 mg/liter for both) and clindamycin demonstrated the least (MIC_{90} = 8 mg/liter), while both clindamycin (MIC_{90} = 16) and piperacillin-tazobactam (MIC_{90} = 32) exhibited the weakest activity against other miscellaneous clostridial isolates. Moxifloxacin exhibited excellent activity against all three species of anaerobic streptococci (*Peptostreptococcus anaerobius*, *Peptostreptococcus magnus*, and *Peptostreptococcus micros*) recovered from surgical patients ($MIC_{90} \leq 1$ mg/liter). The activities of the other agents tested against these strains were highly variable depending on the species, although imipenem was the most active overall (MIC_{90} = 0.12 mg/liter) and metronidazole was the least active (MIC_{90} ranged from 1 to 4 mg/liter) of all agents tested. Moxifloxacin exhibited excellent activity against *Fusobacterium mortiferum* and *F. nucleatum* ($MIC_{90} \leq 1$ mg/liter), although some uncommon strains (specifically *F. varium* and *F. russii*) demonstrated resistance. Clindamycin, imipenem, and metronidazole were the most potent agents tested against *F. mortiferum* and *F. nucleatum* ($MIC_{90} \leq$ 0.5 mg/liter). Against *Porphyromonas* and *Prevotella* species, moxifloxacin demonstrated good activity ($MIC_{90} \leq 2$ mg/liter); however, clindamycin, imipenem, and piperacillin-tazobactam demonstrated more potent in vitro activity ($MIC_{90} \leq 0.25$ mg/liter). Both imipenem and moxifloxacin exhibited similar in vitro activities against *Eubacterium lentum* ($MIC_{90} \leq 0.5$ mg/liter). Overall, by using a breakpoint of ≤4 mg/liter, 97.1% of anaerobic strains were found to be susceptible to moxifloxacin.

Moxifloxacin demonstrates broad-spectrum in vitro activity against both gram-positive and gram-negative aerobic and anaerobic surgical isolates compared to other anti-infectives commonly used in the treatment of surgical infections. Empirical therapy of mixed, aerobic, and anaerobic infections remains challenging because of the rising resistance rates of surgical pathogens, such as *E. coli* and *B. fragilis*. Data collected from 1987 to 1999 revealed that 22% of *B. fragilis* isolates from bloodstream infections were resistant to clindamycin (2). In the same surveillance study, however, ≥96% of *B. fragilis* strains were susceptible to imipenem, metronidazole, and trovafloxacin (the only quinolone tested). Inappropriate therapy for serious anaerobic infections (e.g., bacteremic complications of peritonitis) has been associated with at least a twofold-increased mortality rate (16, 20) as well as significantly increased rates of clinical and bacteriologic failure (20).

In the present study, moxifloxacin demonstrated good to excellent activity against over 19 species of anaerobic bacteria. These data support the results of previous studies that found moxifloxacin to be highly active against clinical isolates of *B. fragilis* (4, 10, 13). However, a recent in vitro study has suggested that quinolone resistance among members of the *B. fragilis* group may be increasing, possibly limiting the therapeutic utility of selective agents (23). It should be noted that the NCCLS has not yet adopted a susceptibility breakpoint for moxifloxacin against the *B. fragilis* group, and therapeutic speculation relative to interpretation of in vitro susceptibility data is at best preliminary. Not unexpectedly, many *B. fragilis* isolates were nonsusceptible to clindamycin based on an MIC_{90} of 4 mg/liter (NCCLS-recommended susceptible breakpoint is ≤2 mg/liter). This high degree of resistance to clindamycin confirms the findings of at least one other recent report wherein only 78% of *B. fragilis* isolates were susceptible to clindamycin (2). Moxifloxacin also demonstrated good to excellent in vitro activity against *Clostridium* spp. and *Fusobac-*

terium spp. isolates from infections involving the peritoneal cavity. In addition, all anaerobic streptococcal isolates from diabetic foot and intra-abdominal infections were susceptible to moxifloxacin.

Selection of an effective antimicrobial agent for a surgical infection requires knowledge of the potential microbial pathogens, an understanding of the pathophysiology of the infectious process, and an understanding of the pharmacology and pharmacokinetics of the intended therapeutic agent (7, 8). Quinolones have been effective in the treatment of selected surgical infections in part because of their excellent activity against aerobic gram-negative bacteria and tissue penetration (9). However, the extended-spectrum and broad-spectrum quinolones do not exhibit potent antianaerobic activity and as such must be used in combination with other therapeutic (antianaerobic) agents. The present study suggests that moxifloxacin exhibits potent activity against both aerobes and anaerobes and may be an effective agent for the treatment of both community- or hospital-acquired intra-abdominal infection and diabetic foot infection, both of which involve a complexed polymicrobial flora (12, 17, 22).

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REFERENCES

1. **Ackermann, G., R. Schaumann, B. Pless, M. C. Caros, E. J. C. Goldstein, and C. Rodloff.** 2000. Comparative activity of moxifloxacin in vitro against obligately anaerobic bacteria. Eur. J. Clin. Microbiol. Infect. Dis. **19:**228–232.
2. **Aldridge, K. E., D. Ashcraft, M. O'Brien, and C. V. Sanders.** 2003. Bacteremia due to *Bacteroides fragilis* group: distribution of species, β-lactamase production, and antimicrobial susceptibility patterns. Antimicrob. Agents Chemother. **47:**148–153.
3. **Appelbaum, P. C.** 1999. Quinolone activity against anaerobes. Drugs **58**(Suppl. 2)**:**60–64.
4. **Behra-Miellet, J., L. Dubreuil, and E. Jumas-Bilak.** 2002. Antianaerobic activity of moxifloxacin compared with that of ofloxacin, ciprofloxacin, clindamycin, metronidazole and beta-lactams. Int. J. Antimicrob. Agents **20:**366–374.
5. **Calhoun, J. H., K. A. Overgaard, C. M. Stevens, J. P. Dowling, and J. T. Mader.** 2002. Diabetic foot ulcers and infections: current concepts. Adv. Skin Wound Care **15:**31–42.
6. **Condon, R. E.** 1999. Microbiology in intraabdominal infections: what is the message for clinical studies? Infection **27:**63–66.
7. **DiPiro, J. T., C. E. Edmiston, and J. M. A. Bohnen.** 1996. Pharmacodynamics of antimicrobial therapy in surgery. Am. J. Surg. **171:**615–622.
8. **Edmiston, C. E., C. Hennen, and G. R. Seabrook.** 2002. The importance of β-lactamase resistance in surgical infections. Surg. Infect. **2**(Suppl. 1)**:**S13–S22.
9. **Edmiston, C. E., E. C. Suarez, A. P. Walker, M. P. Demeure, C. T. Frantzides, W. J. Schulte, and S. D. Wilson.** 1996. Penetration of ciprofloxacin and fleroxacin into the biliary tract. Antimicrob. Agents Chemother. **40:**787–791.
10. **Ednie, L. M., A. Rattan, M. R. Jacobs, and P. C. Appelbaum.** 2003. Antianaerobe activity of RBX 7644 (ranbezolid), a new oxazolidinone, compared with those of eight other agents. Antimicrob. Agents Chemother. **47:**1143–1147.
11. **Gajjar, D. A., F. P. LaCreta, G. D. Kollia, R. R. Stolz, S. Berger, W. B. Smith, M. Swingle, and D. M. Grasela.** 2000. Effect of multiple-dose gatifloxacin or ciprofloxacin on glucose homeostasis and insulin production in patients with noninsulin-dependent diabetes mellitus maintained with diet and exercise. Pharmacotherapy **20:**76S–86S.
12. **Goldstein, E. J. C.** 2002. Intra-abdominal anaerobic infections: bacteriology and therapeutic potential of newer antimicrobial carbapenem, fluoroquinolone, and desfluoroquinolone therapeutic agents. Clin. Infect. Dis. **35**(Suppl. 1)**:**S106–S111.
13. **MacGowan, A. P., K. E. Bowker, H. A. Holt, N, Wootton, and D. S. Reeves.** 1997. Bay 12–8039, a new 8-methoxy-quinolone: comparative in-vitro activity with nine other antimicrobials against anaerobic bacteria. J. Antimicrob. Chemother. **40:**503–509.
14. **Mandell, L. A., P. Ball, and G. Tillotson.** 2001. Antimicrobial safety and tolerability: differences and dilemmas. Clin. Infect. Dis. **32**(Suppl. 1)**:**S72–S79.
15. **Menzies, D. J., P. A. Dorsainvil B. A. Cunha, and D. H. Johnson.** 2002. Severe and persistent hypoglycemia due to gatifloxacin interaction with oral hypoglycemic agents. Am. J. Med. **113:**232–234.
16. **Montravers, P., R. Gauzit, C. Muller, J. P. Marmuse, A. Fichelle, and J. M. Desmonts.** 1996. Emergence of antibiotic-resistant bacteria in cases of peritonitis after intraabdominal surgery affects the efficacy of empirical antimicrobial therapy. Clin. Infect. Dis. **23:**486–494.
17. **Nathans, A. B., and O. D. Rotstein.** 1996. Antimicrobial therapy for intraabdominal infection. Am. J. Surg. **172:**1S–6S.
18. **National Committee for Clinical Laboratory Standards.** 2000. Method for dilution antimicrobial susceptibility testing for bacteria that grow aerobically, 5th ed. Approved standard. NCCLS publication M7-A5. National Committee for Clinical Laboratory Standards, Wayne, Pa.
19. **National Committee for Clinical Laboratory Standards.** 2001. Methods for antimicrobial susceptibility testing of anaerobic bacteria, 5th ed. Approved standard. NCCLS publication M11-A5. National Committee for Clinical Laboratory Standards, Wayne, Pa.
20. **Nguyen, M. H., V. L. Yu, A. J. Morris, L. McDermott, M. W. Wagener, L. Harrell, and D. R. Snydman.** 2000. Antimicrobial resistance and clinical outcome of *Bacteroides* bacteremia: findings of a multicenter prospective observational trial. Clin. Infect. Dis. **30:**870–876.
21. **Parilo, M. A.** 2002. Gatifloxacin-associated hypoglycemia. J. Pharm. Technol. **18:**319–320.
22. **Seabrook, G. R., and J. B. Towne.** 2000. Management of foot lesions in the diabetic patient, p. 1093–1101. *In* R. B. Rutherford (ed.), Vascular surgery, 5th ed. W. B. Saunders, Philadelphia, Pa.
23. **Snydman, D. R., N. V. Jacobus, L. A. McDermott, R. Ruthazer, E. Goldstein, S. Fineglod, L. Harrell, D. W. Hecht, S. Jenkins, C. Pierson, R. Venezia, J. Rihs, and S. L. Gorbach.** 2002. In vitro activities of newer quinolones against *Bacteroides* group organisms. Antimicrob. Agents Chemother. **46:**3276–3279.