ANTIMICROBIAL AGENTS AND CHEMOTHERAPY, Apr. 1990, p. 657–659 Vol. 34, No. 4
0066-4804/90/040657-03$02.00/0

Susceptibilities of *Bacteroides* and *Fusobacterium* spp. from Foot Rot in Goats to 10 β-Lactam Antibiotics

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The agar dilution method was used to determine the bacteriostatic activities of 10 β-lactam antibiotics against 132 strains belonging to the genus *Bacteroides* and 25 strains belonging to the genus *Fusobacterium*, all isolated from clinical cases of caprine foot rot. The three ureidopenicillins studied proved to be the most effective antimicrobial agents.

Foot rot is an infectious disease caused by the synergic action of different microbial species and specific to sheep and goats, although it is also reported in cattle. Microorganisms of the genus *Bacteroides* (mainly *B. nodosus*) and the genus *Fusobacterium* (mainly *F. necrophorum*) have been reported as the etiological agents of ovine (7, 14, 16, 25), bovine (6), and caprine (10) foot rot. A wide range of chemotherapeutic agents for topical and parenteral use have been recommended to check this disease, but few quantitative studies have been done to determine the in vitro susceptibilities of these microorganisms to different antimicrobial agents (15, 18, 30). The purpose of this study was to determine the susceptibilities of *Bacteroides* and *Fusobacterium* strains isolated from clinical cases of caprine foot rot to 10 β-lactam antibiotics (penicillin G, ampicillin, azlocillin, mezlocillin, piperacillin, cefuroxime, cefoperazone, cefotaxime, cefoxitin, and imipenem).

The study was done with 132 strains belonging to the genus *Bacteroides* and 25 strains from the genus *Fusobacterium* isolated from 120 goats with clinical signs of foot rot. The goats came from 13 different flocks in the province of Cáceres, Spain. The strains were identified by the criteria in the *Wadsworth Anaerobic Bacteriology Manual* (32) and the Virginia Polytechnic Institute *Anaerobe Laboratory Manual* (19).

MICs were determined by the proposed standard reference agar dilution procedure for antimicrobial susceptibility testing of anaerobic bacteria (22). Wilkins-Chalgren agar (Oxoid Ltd., Basingstoke, United Kingdom) was used. The plates were incubated at 37°C in GasPak jars (BBL Microbiology Systems, Cockeysville, Md.) for 48 h. Two control strains from the American Type Culture Collection (Rockville, Md.) were included in all MIC determinations: *Bacteroides fragilis* ATCC 25285 and *Clostridium perfringens* ATCC 13124.

The MICs of 10 β-lactam antibiotics for 132 strains of the genus *Bacteroides* isolated from foot rot in goats are shown in Table 1. The susceptibilities to β-lactam antibiotics of the 25 *Fusobacterium* strains studied are shown in Table 2.

The susceptibilities to penicillin G of the *Bacteroides* strains isolated in this study are similar to those reported by Benno and Mitsouka (5) for *B. helcogenes* isolated from abscesses in swine and by Gradin and Schmitz (18) for *B. nodosus* obtained from foot rot in sheep. Results similar to those obtained in the present study have been reported (1, 9, 29, 34) for bacteria belonging to the *Bacteroides melaninogenicus-B. oralis* group. The 12 *F. necrophorum* strains studied here were more resistant to penicillin G than were those isolated by Baba et al. (2) from bovine hepatic abscesses and by Ikawa et al. (20) from uterine pyemia in cattle. Ampicillin showed good activity against the microorganisms isolated in this study. This is not commonly the case with bacteria isolated from humans (1, 4, 34, 35).

The degrees of effectiveness of azlocillin, mezlocillin, and piperacillin found in this study are similar to those reported by Sutter and Finegold (34) for nine *B. melaninogenicus* strains and several *Fusobacterium* species. Others (8, 24) have reported similar results. This suggests that, a priori, the use of some of these ureidopenicillins (azlocillin, mezlocillin, and piperacillin) might be of value in the treatment of foot rot.

The rate of resistance of *B. nodosus* to cefuroxime in this study is not comparable to the values reported by Gradin and Schmitz (18) for 18 *B. nodosus* strains tested against cefamandole (MIC range, 0.06 to 1 μg/ml). The other two species which were resistant to 16 μg of cefuroxime per ml were *Bacteroides buccae* (6.1%) and *B. ruminicola* subsp. *brevis* (4.5%). Of the *Fusobacterium* strains studied, 20% were resistant at a concentration of 16 μg/ml, and 16% were resistant at a greater concentration. George et al. (17) and Sutter and Finegold (33) reported similar results. The values obtained for cefoperazone and cefotaxime were practically the same for the 132 *Bacteroides* strains studied, with 6.8% resistant to 16 μg/ml in both cases. Similar resistance rates have been described by Sedallian (28) with 39 *B. oralis* and *B. bivius* strains and 33 *B. asaccharolyticus* strains. However, Cuchural et al. (11), Rosenblatt (27), and Tally et al. (36) reported considerably higher resistance rates in *B. fragilis* group strains, although it should be borne in mind that these strains are β-lactamase producers. Rates of resistance to cefoperazone and cefotaxime obtained in this study for 25 *Fusobacterium* strains are lower than those reported by George et al. (17) for *F. varium* and *F. naviforme* isolated from normal populations and from human infections.

Cefoxitin activity against the 132 *Bacteroides* strains (12.9% of strains resistant to 16 μg/ml) was similar to that described by others (3, 11, 12, 24, 27, 28, 31, 33, 36). In all cases, resistance rates were around 15%. The rates of resistance to cefoxitin recorded in this study for *F. necrophorum*, *F. mortiferum*, and *F. naviforme* were higher than those reported by Dubreuil et al. (13) for 14 *Fusobacterium*

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TABLE 1. Susceptibilities of 132 *Bacteroides* strains isolated from cases of caprine foot rot

Species (no. of strains tested)	Antimicrobial agent	MIC[a]		
		Range	50%	90%
B. buccae (65)	Penicillin G	≤0.06–≥256	0.5	32
	Ampicillin	≤0.06–64	0.5	8
	Azlocillin	≤0.06–32	0.5	8
	Piperacillin	≤0.06–8	0.25	4
	Mezlocillin	≤0.06–32	0.12	8
	Cefuroxime	≤0.06–32	4	16
	Cefoperazone	≤0.06–64	1	32
	Cefotaxime	≤0.06–64	1	32
	Cefoxitin	≤0.06–≥256	0.25	16
	Imipenem	≤0.06–16	0.12	4
B. nodosus (37)	Penicillin G	≤0.06–32	0.12	2
	Ampicillin	≤0.06–4	0.12	2
	Azlocillin	≤0.06–32	0.25	4
	Piperacillin	≤0.06–2	0.25	2
	Mezlocillin	≤0.06–4	0.25	4
	Cefuroxime	≤0.06–32	0.25	32
	Cefoperazone	≤0.06–32	1	16
	Cefotaxime	≤0.06–32	0.12	8
	Cefoxitin	≤0.06–64	1	64
	Imipenem	≤0.06–16	0.5	16
B. ruminicola subsp. *brevis* (22)	Penicillin G	≤0.06–128	0.5	32
	Ampicillin	≤0.06–4	0.5	4
	Azlocillin	≤0.06–64	0.5	16
	Piperacillin	≤0.06–128	0.25	4
	Mezlocillin	≤0.06–32	≤0.06	4
	Cefuroxime	≤0.06–128	4	8
	Cefoperazone	≤0.06–8	1	2
	Cefotaxime	≤0.06–8	2	4
	Cefoxitin	≤0.06–≥256	0.12	4
	Imipenem	≤0.06–0.5	0.12	0.5
Other *Bacteroides* (8)[b]	Penicillin G	≤0.06–1	≤0.06	
	Ampicillin	≤0.06–4	≤0.06	
	Azlocillin	≤0.06–1	≤0.06	
	Piperacillin	≤0.06–0.5	≤0.06	
	Mezlocillin	≤0.06	≤0.06	
	Cefuroxime	≤0.06–4	≤0.06	
	Cefoperazone	≤0.06–16	2	
	Cefotaxime	≤0.06–1	≤0.06	
	Cefoxitin	≤0.06–1	0.12	
	Imipenem	≤0.06–1	0.12	

[a] MICs of all agents except penicillin G are given in micrograms per milliliter. Penicillin G MICs are in units per milliliter. 50% and 90%, MICs for 50 and 90% of strains tested, respectively.

[b] Including three *B. levii*, three *B. splanchnicus*, one *B. putredinis*, and one *B. macacae* isolate.

strains. Phillips et al. (24), Sedallian (28), and Sutter and Finegold (33) found no strains resistant to cefoxitin.

Finally, the activity recorded for imipenem against *Bacteroides* strains has also been reported by others (21, 23, 24, 26). However, this antimicrobial agent was less effective against the 25 *Fusobacterium* strains, resistance being recorded in *F. necrophorum*, *F. mortiferum*, and *F. naviforme*. Values obtained for other *Fusobacterium* species were similar to those reported by Phillips et al. (24), all such species being susceptible to imipenem.

We thank E. Fernández Corrales for technical assistance.

This study was done as part of a research project supported by the Extremadura Regional Government Council for Education and Science (Spain).

TABLE 2. Susceptibilities of 25 *Fusobacterium* strains isolated from cases of caprine foot rot

Species (no. of strains tested)	Antimicrobial agent	MIC[a]		
		Range	50%	90%
F. necrophorum (12)	Penicillin G	≤0.06–128	0.12	128
	Ampicillin	≤0.06–16	≤0.06	4
	Azlocillin	≤0.06–8	≤0.06	8
	Piperacillin	≤0.06–8	0.25	4
	Mezlocillin	≤0.06–4	0.25	4
	Cefuroxime	≤0.06–≥256	1	≥256
	Cefoperazone	≤0.06–128	0.5	64
	Cefotaxime	≤0.06–≥256	1	≥256
	Cefoxitin	≤0.06–128	0.5	64
	Imipenem	≤0.06–64	2	32
Other *Fusobacterium* (13)[b]	Penicillin G	≤0.06–32	2	32
	Ampicillin	≤0.06–≥256	0.5	4
	Azlocillin	≤0.06–≥256	0.25	64
	Piperacillin	≤0.06–32	0.12	8
	Mezlocillin	≤0.06–32	0.12	16
	Cefuroxime	≤0.06–64	0.25	32
	Cefoperazone	≤0.06–16	≤0.06	16
	Cefotaxime	≤0.06–32	0.5	8
	Cefoxitin	≤0.06–64	0.5	64
	Imipenem	≤0.06–128	0.5	16

[a] MICs of all agents except penicillin G are given in micrograms per milliliter. Penicillin G MICs are in units per milliliter. 50% and 90%, MICs for 50 and 90% of strains tested, respectively.

[b] Including four *F. mortiferum*, three *F. naviforme*, two *F. prausnitzii*, two *F. sulci*, one *F. necrogenes*, and one *F. perfoetens* isolate.

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