

## Antimicrobial Susceptibility of *Staphylococcus saprophyticus* and Urethral Staphylococci

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The activity of eight antimicrobial agents was determined against 115 isolates of *Staphylococcus saprophyticus*. All were susceptible to ampicillin, cephalixin, and trimethoprim-sulfamethoxazole and resistant to nalidixic acid and novobiocin. A bimodal pattern of susceptibility to erythromycin was observed: 80% were inhibited by 0.25 µg/ml, whereas 13% required ≥128 µg/ml. The following urethral staphylococci were susceptible to ampicillin, cephalixin, and nitrofurantoin but resistant to nalidixic acid: *S. epidermidis*, *S. hominis*, *S. haemolyticus*, *S. warneri*, *S. simulans*, and *S. cohnii*.

*Staphylococcus saprophyticus* has now been shown to be an important cause of urinary tract infection in young adult females (1-4, 6, 8, 12). However, there are still very few data on the antimicrobial susceptibility of this microorganism (4, 5, 8, 9). We determined the susceptibility of *S. saprophyticus* to eight antimicrobial agents, and we also determined the activity of five of these agents against isolates of coagulase-negative staphylococci recovered from the urethras of healthy females.

### MATERIALS AND METHODS

**Bacteria.** The isolates of *S. saprophyticus* were from the midstream urine specimens of 115 women with symptoms of a urinary tract infection. These were identified as *S. saprophyticus* by a modification (carbohydrate fermentation reactions were performed in broth rather than in agar) of the method of Kloos and Schleifer (7). The remaining species of staphylococci were isolated from urethral urine specimens obtained from healthy women of reproductive age as part of a study of urethral flora and from women with the urethral syndrome. These organisms were classified by species as outlined above. Only single isolates of each species from each person were tested.

The following control organisms were included with each run: *S. aureus* ATCC 25923, *Escherichia coli* ATCC 25922, *S. saprophyticus* ATCC 15305, and Oxford *S. aureus*.

**Media and susceptibility tests.** Organisms to be tested were inoculated into tryptose phosphate broth (Difco Laboratories, Detroit, Mich.) and incubated at 37°C for 6 h. Turbidity was adjusted with tryptose phosphate broth to that of one-half the no. 1 McFarland standard. An agar dilution susceptibility test was performed as described by Washington and Sutter (13). A Steers replicator (11) was used to inoculate the suspension to the Mueller-Hinton agar (GIBCO Diag-

nostics, Madison, Wis.). A plate of test medium without antibiotics was inoculated at the beginning and end of each series of tests to serve as a growth control. The plates were then incubated at 37°C for 18 h. The minimal inhibitory concentration was read as the lowest concentration of antimicrobial agent yielding no growth.

**Antimicrobial agents.** Laboratory standard powders were supplied as follows: ampicillin, Ayerst Laboratories, Montreal, Quebec, Canada; benzylpenicillin G, Glaxo Laboratories, Toronto, Ontario, Canada; trimethoprim lactate and sulfamethoxazole, Burroughs Wellcome Ltd., La Salle, Quebec, Canada; erythromycin, Abbott Laboratories, Montreal, Quebec, Canada; nalidixic acid, Winthrop Laboratories, Aurora, Ontario, Canada; and nitrofurantoin, Norwick-Eaton Pharmaceuticals, Paris, Ontario, Canada.

The sulfamethoxazole and nalidixic acid were dissolved in 0.1 N NaOH. The nitrofurantoin was dissolved in dimethylformamide and subsequently diluted in 25% dimethylformamide in water. All other antibiotic powders were diluted in water.

### RESULTS AND DISCUSSION

All 115 isolates of *S. saprophyticus* were susceptible to ampicillin, cephalixin, and trimethoprim-sulfamethoxazole, and all were resistant to nalidixic acid and novobiocin (Table 1).

All urethral staphylococci except *S. cohnii* were susceptible to novobiocin (Table 2). *S. cohnii* and *S. xylosus* have previously been shown to be resistant to novobiocin (10).

*S. cohnii* has been isolated more frequently from urine specimens than has *S. xylosus* (5). We have not recovered *S. cohnii* from the urethras of 100 healthy young women (7a). These organisms then represent false-positives if resistance to the 5-µg novobiocin disk is used as

TABLE 1. Comparative activities of eight antimicrobial agents against 115 *S. saprophyticus* isolates

Antibiotic	Minimal inhibitory concn ( $\mu\text{g/ml}$ )		
	50%	90%	Range
Ampicillin	0.25	0.25	$\leq 0.25-8$
Penicillin	0.125	0.125	$\leq 0.125-4$
Cephalexin	4	4	1-8
Nitrofurantoin	64	64	16-64
Nalidixic acid	>256	>256	
Erythromycin	0.25	128	0.25->256
Trimethoprim-sulfamethoxazole	0.25-4.75	0.5-9.5	$\leq 0.125-2.5-2.375-47.5$
Novobiocin	16	32	16-32

a presumptive test for the identification of *S. saprophyticus* (2).

Most isolates of *S. saprophyticus* were resistant to nitrofurantoin at a minimal inhibitory concentration of 64  $\mu\text{g/ml}$ . All of the other coagulase-negative staphylococci were suscepti-

ble to nitrofurantoin (Table 2). Of all *S. saprophyticus* isolates, 80% were inhibited by 0.25  $\mu\text{g}$  of erythromycin per ml, but 13% were highly resistant, requiring  $\geq 128 \mu\text{g/ml}$ . All of the isolates of staphylococci from the urethras of healthy females (Table 2) were inhibited by

TABLE 2. Comparative activities of five antimicrobial agents against various species of coagulase-negative staphylococci isolated from the urethras of healthy females and from women with the urethral syndrome

Organism (no. of isolates)	Antibiotic	Minimal inhibitory concn ( $\mu\text{g/ml}$ )		
		50%	90%	Range
<i>S. epidermidis</i> (30)	Ampicillin	0.25	16	$\leq 0.125-16$
	Cephalexin	2	2	0.5-8
	Nitrofurantoin	16	16	16-32
	Nalidixic acid	64	64	32-128
	Novobiocin	0.125	0.125	$\leq 0.125$
<i>S. hominis</i> (25)	Ampicillin	0.125	2	$\leq 0.125-2$
	Cephalexin	2	4	1-16
	Nitrofurantoin	32	32	16-32
	Nalidixic acid	64	128	32->256
	Novobiocin	0.25	0.25	$\leq 0.125-0.25$
<i>S. haemolyticus</i> (16)	Ampicillin	0.25	1	$\leq 0.125-2$
	Cephalexin	1	2	2-4
	Nitrofurantoin	32	32	16-32
	Nalidixic acid	64	64	32-64
	Novobiocin	0.25	0.5	$\leq 0.125-0.5$
<i>S. warneri</i> (8)	Ampicillin	0.125	4	$\leq 0.125-4$
	Cephalexin	2	4	1-4
	Nitrofurantoin	32	32	16-32
	Nalidixic acid	128	128	32-128
	Novobiocin	0.125	0.25	$\leq 0.125-0.5$
<i>S. simulans</i> (7)	Ampicillin	0.125	0.125	$\leq 0.125$
	Cephalexin	4	4	2-4
	Nitrofurantoin	32	32	16-32
	Nalidixic acid	64	128	64-128
	Novobiocin	0.125	0.25	$\leq 0.125-0.25$
<i>S. cohnii</i> (4)	Ampicillin	0.125	0.25	$\leq 0.125-0.25$
	Cephalexin	4	4	2-4
	Nitrofurantoin	32	32	16-32
	Nalidixic acid	>256	>256	256->256
	Novobiocin	16	32	16-32

concentrations of ampicillin and cephalixin achievable in the urine.

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