Antimicrobial Activity of Ceftaroline Tested Against Streptococci from United States (USA) and European (EU) Medical Centers: Results from the Ceftaroline Surveillance Program

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Amended Abstract

Background: Ceftaroline (CPT), a novel broad spectrum cephalosporin with anti-MRSA activity, was evaluated against contemporary clinical streptococcal strains. In order to monitor recent in vitro activity of CPT, a large multicenter study in the USA and Europe was conducted.

Methods: 2,044 patient unique isolates were consecutively collected in USA and EU medical centers (54) in 2008. Susceptibility (S) was tested by CLSI broth microdilution methods against CPT and various comparators.

Results: Penicillin (PEN) S (≤0.06/≤2 μg/mL) among *S. pneumoniae* (SPN) were 58/87% in the USA and 73/92% in EU. CPT (MIC_{90}/highest MIC, 0.12/0.5 μg/mL) was 8-fold more potent than ceftriaxone (CRO; MIC_{90}, 1 μg/mL; 91% S) and 32- to 64-fold more potent than cefuroxime (FUR; MIC_{90}, 4-8 μg/mL; 70-80% S). SPN S to amoxicillin/clavulanate (A/C), azithromycin, trimethoprim/sulfamethoxazole and levofloxacin (LEV) were (USA/EU): 83/93, 59/66, 66/71 and 99/97%, respectively. Against β-haemolytic streptococci (βHS), CPT was 2- to 4-fold more potent than PEN (MIC_{90}, 0.06 μg/mL) and 32- to ≥128-fold more potent than linezolid or LEV (MIC_{90}, 1 μg/mL for both). All βHS strains were inhibited at ≤0.06 μg/mL of CPT and LEV R was observed in 4 βHS from the USA. CPT was also very active against viridans gr. streptococci (VGS; MIC_{90}, 0.12 μg/mL) and all isolates except 1 were inhibited at ≤1 μg/mL of CPT. S to PEN, CRO and LEV among VGS were (USA/EU): 72/78, 90/92 and 86/89%, respectively.

Organism (no. tested [USA/EU])	Cumulative % (USA/EU) inhibited at ceftaroline MIC (μg/mL) of: ≤0.008	0.016	0.03	0.06	0.12	0.25	0.5	1
S. pneumoniae								
PEN-S[a] (521/327)	84/85	96/97	99/99	100/100	-	-	-	-
PEN-I[a] (178/41)	4/5	34/20	54/54	93/88	100/98	100/100	-	-
PEN-R[a] (195/78)	0/0	0/1	1/3	4/6	61/72	94/99	100/100	-
PEN MIC ≥8 μg/ml (9/0)	0/-	0/-	0/-	0/-	0/-	44/-	100/-	-
β-haemolytic strep. (327/179)	50/60	90/93	>99/>99	100/100	-	-	-	-
Viridans gr. strep. (110/88)	24/22	46/50	79/76	87/88	93/89	96/93	97/97	100/99

a. PEN-S: penicillin MIC, ≤0.06 μ/mL; PEN-I: penicillin MIC, 0.12-1 μg/mL; PEN-R: penicillin MIC, ≥2 μg/mL.

Conclusions: CPT exhibited broad-spectrum and high potency against streptococci recently collected in USA and EU centers, including SPN non-S to A/C (7-17%), CRO (9%) or LEV (1-3%). S rates were generally lower in the USA compared to EU.

Introduction

Ceftaroline is a novel, parenteral, broad-spectrum cephalosporin exhibiting bactericidal activity against gram-positive organisms, including methicillin-resistant *Staphylococcus aureus* (MRSA) and multidrug-resistant *Streptococcus pneumoniae* (MDRSP), as well as common gram-negative pathogens. Ceftaroline is currently being evaluated for the treatment of bacterial infections caused by gram-positive pathogens, including staphylococci and streptococci, as well as common gram-negative species, including *Haemophilus influenzae* and *Enterobacteriaceae*.

S. pneumoniae is the main bacterial cause of community-acquired respiratory tract infections (CARTI), especially community-acquired bacterial pneumonia (CABP). Although the broad use of the pneumococcal conjugate vaccine led to an initial decrease in the incidence of disease caused by resistant strains, the number of highly resistant pneumococcal strains not covered by the vaccine has been increasing.

Although β-haemolytic streptococci are considered among the most important pathogens associated with skin and skin-structure infections (SSSI), viridians group streptococci are also considered relevant pathogens associated with some types of SSSI or disseminated disease. Ceftaroline provides excellent in vitro activity against these gram-positive pathogens, including MDR strains.

In the present study, we evaluated the antimicrobial activity and spectrum of ceftaroline and comparator agents tested against clinical bacterial isolates of streptococci collected in medical centers located throughout the United States (USA) and Europe.

Materials and Methods

Bacterial Isolates

All organisms were isolated from documented infections and only 1 strain per patient infection episode was included in the surveillance. The organisms were collected from medical centers located in the USA (27) and 12 European countries plus Israel (28).

Susceptibility Testing

The isolates were tested for susceptibility to ceftaroline and numerous comparator agents by broth microdilution methods using validated panels manufactured by TREK Diagnostics (Cleveland, Ohio) and following the Clinical and Laboratory Standards Institute (CLSI) recommendations (M07-A8, 2009). Organisms were tested in Mueller-Hinton broth supplemented with 3-5% lysed horse blood. Concurrent testing of quality control (QC) strains determined that proper test conditions were applied. These strains included *S. pneumoniae* ATCC 49619 and *S. aureus* ATCC 29213.

Results

- The highest ceftaroline MIC values observed among penicillin-susceptible (MIC, ≤0.06 μg/mL), penicillin-intermediate (MIC, 0.12 – 1 μg/mL), and penicillin-resistant (MIC, ≥2 μg/mL) strains of *S. pneumoniae* were 0.06, 0.25, and 0.5 μg/mL, respectively (Table 3); while the MIC_{90} varied from ≤0.008 μg/mL for the penicillin-susceptible to 0.12 μg/mL for the penicillin-resistant strains (Tables 1 and 2).
- As with other β-lactams, the in vitro activity of ceftaroline increased with increasing susceptibility to penicillin. Ceftaroline was the most potent of all β-lactams tested against *S. pneumoniae* strains (Tables 1 and 2).
- Against penicillin-resistant pneumococci (MIC, ≥2 μg/mL), ceftaroline (MIC_{50}, 0.12 μg/mL and MIC_{90}, 0.25 μg/mL) was 8- to 16-fold more potent than ceftriaxone (MIC_{50}, 1-2 μg/mL and MIC_{90}, 2 μg/mL) and 16- to 64-fold more potent than amoxicillin/clavulanic acid (MIC_{50}, 2-8 μg/mL and MIC_{90}, 8 μg/mL; Tables 1 and 2).
- Among *S. pneumoniae*, penicillin susceptibility rates (meningitis [≤0.06 μg/mL]/nonmeningitis [≤2 μg/mL] breakpoints) were 58.3%/86.5% in the USA and 73.3%/91.9% in Europe. Susceptibility rates to ceftriaxone were similar in the USA and Europe (90.8%); however, susceptibilities to amoxicillin/clavulanate and cefuroxime were significantly lower in the USA (83.3% and 70.3%, respectively) than in Europe (93.3% and 79.8%, respectively). Only 61.6% to 66.4% of strains were susceptible to erythromycin (Tables 1 and 2).
- Penicillin-resistant strains (MIC, ≥2 μg/mL) exhibited low susceptibility to most antimicrobial agents, including (USA/Europe): amoxicillin-clavulanate (23.6/62.8%), ceftriaxone (59.0/48.7%), erythromycin (15.4/14.1%), and clindamycin (36.9/46.2%; Tables 1 and 2).
- Ceftaroline was also very active against *S. pneumoniae* strains, with penicillin MIC of ≥8 μg/mL (9 isolates from the USA). Ceftaroline MIC values ranged from 0.25 (4 strains) to 0.5 μg/mL (5 strains; Table 3). None of these isolates was susceptible to other β-lactam agents tested. Ceftaroline (MIC_{50}, 0.5 μg/mL) was 8-fold more active than ceftriaxone (MIC_{50}, 4 μg/mL) against this group of organisms (Table 1).
- β-haemolytic streptococci were very susceptible to ceftaroline, with MIC_{90} results ranging from 0.015 to 0.03 μg/mL. The highest ceftaroline MIC among β-haemolytic streptococci was only 0.06 μg/mL (Table 3)
- Ceftaroline was highly active against viridans group streptococci from the USA (MIC_{50}, 0.03 μg/mL and MIC_{90}, 0.12 μg/mL) and Europe (MIC_{50}, 0.015 μg/mL and MIC_{90}, 0.25 μg/mL). Ceftaroline was 4- to 8-fold more active than penicillin (MIC_{90}, 0.06-0.12 μg/mL and MIC_{90}, 1-2 μg/mL) and 4- to 16-fold more potent than cefepime (MIC_{50}, ≤0.12-0.25 μg/mL and MIC_{90}, 1-2 μg/mL) or ceftriaxone (MIC_{50}, ≤0.25 μg/mL and MIC_{90}, 1-2 μg/mL) against this organism group (Tables 1 to 3).

Table 1. In Vitro Activity of Ceftaroline and Selected Antimicrobial Agents Tested Against Streptococcal Isolates from the USA (2008).

Organism (no. tested)/Antimicrobial Agent	MIC_{50}	MIC_{90}	Range	% Susceptible	% Resistant[a]
S. pneumoniae (894)					
Ceftaroline	0.015	0.12	≤0.008 – 0.5	-	-
Penicillin[b]	≤0.03	4	≤0.03 – >4	86.5	1.0
Penicillin[c]	≤0.03	4	≤0.03 – >4	58.3	21.8
Amoxicillin/clavulanate	≤1	8	≤1 – 16	83.3	13.2
Ceftriaxone	≤0.25	1	≤0.25 – 8	90.8	2.2
Cefuroxime	≤1	8	≤1 – >8	70.3	25.9
Erythromycin	≤0.25	>2	≤0.25 – >2	61.6	38.0
Azithromycin	≤0.5	>4	≤0.5 – >4	59.2	40.3
Clarithromycin	≤0.25	>32	≤0.25 – >32	59.7	39.9
Clindamycin	≤0.25	>2	≤0.25 – >2	79.3	20.5
Levofloxacin	1	1	≤0.5 – >4	99.4	0.4
Trimethoprim/sulfamethoxazole	≤0.5	>2	≤0.5 – >2	66.3	24.9
Vancomycin	1	1	≤1 – 1	100.0	-
Penicillin-susceptible *S. pneumoniae* (MIC, ≤0.06 μg/mL; 521)					
Ceftaroline	≤0.008	0.015	≤0.008 – 0.06	-	-
Amoxicillin/clavulanate	≤1	≤1	≤1 – 2	100.0	0.0
Ceftriaxone	≤0.25	≤0.25	≤0.25 – 0.5	100.0	0.0
Cefuroxime	≤1	≤1	≤1 – 2	99.8	0.0
Erythromycin	≤0.25	>2	≤0.25 – >2	86.8	12.9
Azithromycin	≤0.5	>4	≤0.5 – >4	86.7	12.8
Clarithromycin	≤0.25	2	≤0.25 – >32	87.5	12.0
Clindamycin	≤0.25	≤0.25	≤0.25 – >2	97.3	2.5
Levofloxacin	1	1	≤0.5 – >4	99.6	0.4
Trimethoprim/sulfamethoxazole	≤0.5	≤0.5	≤0.5 – >2	90.6	3.5
Vancomycin	≤1	≤1	≤1	100.0	-
Penicillin-intermediate *S. pneumoniae* (MIC, 0.12-1 μg/mL; 178)					
Ceftaroline	0.03	0.06	≤0.008 – 0.12	-	-
Amoxicillin/clavulanate	≤1	≤1	≤1 – 2	100.0	0.0
Ceftriaxone	≤0.25	0.5	≤0.25 – 4	98.9	0.6
Cefuroxime	≤1	4	≤1 – 8	71.2	12.8
Erythromycin	>2	>2	≤0.25 – >2	38.8	60.7
Azithromycin	>4	>4	≤0.5 – >4	37.4	62.6
Clarithromycin	2	>32	≤0.25 – >32	37.4	62.6
Clindamycin	≤0.25	>2	≤0.25 – >2	73.0	27.0
Levofloxacin	1	1	≤0.5 – >4	99.4	0.6
Trimethoprim/sulfamethoxazole	1	>2	≤0.5 – >2	43.3	34.8
Vancomycin	1	1	≤1 – 1	100.0	-
Penicillin-resistant *S. pneumoniae* (MIC, ≥2 μg/mL; 195)					
Ceftaroline	0.12	0.25	0.03 – 0.5	-	-
Penicillin[b]	4	4	2 – >4	37.9	4.6
Amoxicillin/clavulanate	8	8	≤1 – 16	23.6	60.5
Ceftriaxone	1	2	≤0.25 – 8	59.0	9.7
Cefuroxime	8	>8	≤1 – >8	0.6	98.3
Erythromycin	>2	>2	≤0.25 – >2	15.4	84.6
Azithromycin	>4	>4	≤0.5 – >4	13.6	85.8
Clarithromycin	>32	>32	≤0.25 – >32	13.6	85.8
Clindamycin	>2	>2	≤0.25 – >2	36.9	62.6
Levofloxacin	1	1	≤0.5 – >4	99.0	0.5
Trimethoprim/sulfamethoxazole	>2	>2	≤0.5 – >2	22.6	73.3
Vancomycin	≤1	≤1	≤1	100.0	-
S. pneumoniae with penicillin MIC of ≥8 μg/mL (9)					
Ceftaroline	0.5	-	0.25 – 0.5	-	-
Penicillin[b]	>4	-	>4	0.0	100.0
Amoxicillin/clavulanate	16	-	8 – 16	0.0	100.0
Ceftriaxone	4	-	2 – 8	0.0	66.7
Cefuroxime	>8	-	>8	0.0	100.0
Erythromycin	>2	-	≤0.06 – >2	11.1	88.9
Azithromycin	>4	-	≤0.5 – >4	14.3	85.7
Clarithromycin	>32	-	≤0.25 – >32	14.3	85.7
Clindamycin	>2	-	≤0.25 – >2	33.3	66.7
Levofloxacin	1	-	≤0.5 – 1	100.0	0.0
Trimethoprim/sulfamethoxazole	>2	-	2 – >2	0.0	88.9
Vancomycin	≤1	-	≤1	100.0	-
β-haemolytic streptococci (327)[d]					
Ceftaroline	≤0.008	0.03	≤0.008 – 0.06	-	-
Ceftriaxone	≤0.25	≤0.25	≤0.25 – 0.5	100.0	-
Cefepime	≤0.12	≤0.12	≤0.12 – 0.5	100.0	-
Imipenem	≤0.12	≤0.12	≤0.12	-	-
Penicillin	≤0.015	0.06	≤0.015 – 0.12	100.0	-
Piperacillin/tazobactam	≤0.5	≤0.5	≤0.5 – 1	-	-
Erythromycin	≤0.25	>2	≤0.25 – >2	73.4	25.4
Clindamycin	≤0.25	>2	≤0.25 – >2	86.2	13.8
Levofloxacin	≤0.5	1	≤0.5 – >4	98.8	0.9
Trimethoprim/sulfamethoxazole	≤0.5	≤0.5	≤0.5 – >2	-	-
Linezolid	1	1	0.12 – 2	100.0	-
Vancomycin	0.5	0.5	0.25 – 1	100.0	-
Viridans group streptococci (110)[e]					
Ceftaroline	0.03	0.12	≤0.008 – 1	-	-
Ceftriaxone	≤0.25	1	≤0.25 – 16	90.0	4.5
Cefepime	≤0.12	2	≤0.12 – 4	88.2	3.6
Imipenem	≤0.12	0.25	≤0.12 – 4	-	-
Penicillin	0.12	1	≤0.015 – 8	71.8	7.3
Piperacillin/tazobactam	≤0.5	8	≤0.5 – 32	-	-
Erythromycin	1	>2	≤0.25 – >2	41.8	54.5
Clindamycin	≤0.25	≤0.25	≤0.25 – >2	91.8	7.3
Levofloxacin	1	>4	≤0.5 – >4	85.5	13.6
Trimethoprim/sulfamethoxazole	≤0.5	2	≤0.5 – >2	-	-
Linezolid	1	1	0.25 – 2	100.0	-
Vancomycin	0.5	0.5	≤0.12 – 1	100.0	-

a. Criteria as published by the CLSI (2009). - = no breakpoint has been established by the CLSI.

b. Criteria as published by the CLSI (2009) for 'Penicillin parenteral (non-meningitis)'.

c. Criteria as published by the CLSI (2009) for 'Penicillin (oral penicillin V)'.

d. Includes: *Streptococcus dysgalactiae* (4 strains), *Streptococcus equi* (1 strain), *Streptococcus equisimilis* (1 strain), Group A *Streptococcus* (132 strains), Group B *Streptococcus* (157 strains), Group C *Streptococcus* (12 strains), Group F *Streptococcus* (4 strains), and Group G *Streptococcus* (16 strains).

e. Includes: *Streptococcus anginosus* (9 strains), *Streptococcus constellatus* (2 strains), *Streptococcus gordonii* (3 strains), *Streptococcus intermedius* (1 strain), *Streptococcus milleri* (4 strains), *Streptococcus mitis* (28 strains), *Streptococcus oralis* (3 strains), *Streptococcus parasanguinis* (11 strains), *Streptococcus salivarius* (4 strains), *Streptococcus sanguinis* (3 strains), *Streptococcus uberis* (1 strain), *Streptococcus vestibularis* (1 strain), unspeciated alpha-haemolytic streptococci (2 strains), and unspecified viridans group streptococci (38 strains).

Table 2. In Vitro Activity of Ceftaroline and Selected Antimicrobial Agents Tested Against Streptococcal Isolates from Europe (2008).

Organism (no. tested)/Antimicrobial agent	MIC_{50}	MIC_{90}	Range	% Susceptible	% Resistant[a]
S. pneumoniae (446)					
Ceftaroline	≤0.008	0.12	≤0.008 – 0.5	-	-
Penicillin[b]	≤0.03	2	≤0.03 – 4	91.9	0.0
Penicillin[c]	≤0.03	2	≤0.03 – 4	73.3	17.5
Amoxicillin/clavulanate	≤1	2	≤1 – 16	93.3	4.5
Ceftriaxone	≤0.25	1	≤0.25 – 4	90.8	0.7
Cefuroxime	≤1	4	≤1 – >8	79.8	18.6
Erythromycin	≤0.25	>2	≤0.25 – >2	66.4	33.6
Azithromycin	≤0.5	>4	≤0.5 – >4	66.9	33.1
Clarithromycin	≤0.25	>32	≤0.25 – >32	66.4	32.4
Clindamycin	≤0.25	>2	≤0.25 – >2	77.6	21.7
Levofloxacin	1	1	≤0.5 – >4	97.1	2.7
Trimethoprim/sulfamethoxazole	≤0.5	>2	≤0.5 – >2	71.1	17.0
Vancomycin	≤1	≤1	≤1	100.0	-
Penicillin-susceptible *S. pneumoniae* (MIC, ≤0.06 μg/mL; 327)					
Ceftaroline	≤0.008	0.015	≤0.008 – 0.06	-	-
Amoxicillin/clavulanate	≤1	≤1	≤1 – 4	99.7	0.0
Ceftriaxone	≤0.25	≤0.25	≤0.25 – 0.5	100.0	0.0
Cefuroxime	≤1	≤1	≤1 – 2	99.4	0.0
Erythromycin	≤0.25	>2	≤0.25 – >2	81.7	18.3
Azithromycin	≤0.5	>4	≤0.5 – >4	81.4	18.0
Clarithromycin	≤0.25	>32	≤0.25 – >32	81.7	17.6
Clindamycin	≤0.25	>2	≤0.25 – >2	86.9	12.8
Levofloxacin	1	1	≤0.5 – >4	97.2	2.4
Trimethoprim/sulfamethoxazole	≤0.5	2	≤0.5 – >2	85.6	7.0
Vancomycin	≤1	≤1	≤1	100.0	-
Penicillin-intermediate *S. pneumoniae* (MIC, 0.12-1 μg/mL; 41)					
Ceftaroline	0.03	0.12	≤0.008 – 0.25	-	-
Amoxicillin/clavulanate	≤1	≤1	≤1 – 2	100.0	0.0
Ceftriaxone	≤0.25	1	≤0.25 – 4	97.6	2.4
Cefuroxime	≤1	4	≤1 – >8	73.2	17.1
Erythromycin	4	>8	≤0.06 – >8	43.9	56.1
Azithromycin	4	>4	≤0.5 – >4	41.5	56.1
Clarithromycin	2	>32	≤0.25 – >32	43.9	56.1
Clindamycin	≤0.25	>2	≤0.25 – >2	63.4	34.1
Levofloxacin	1	1	≤0.5 – 2	100.0	0.0
Trimethoprim/sulfamethoxazole	≤0.5	>2	≤0.5 – >2	56.1	34.1
Vancomycin	≤1	≤1	≤1	100.0	-
Penicillin-resistant *S. pneumoniae* (MIC, ≥2 μg/mL; 78)					
Ceftaroline	0.12	0.25	0.015 – 0.5	-	-
Penicillin[c]	2	4	2 – 4	53.8	0.0
Amoxicillin/clavulanate	2	8	≤1 – 16	62.8	25.6
Ceftriaxone	2	2	0.5 – 4	48.7	2.6
Cefuroxime	4	8	≤1 – >8	1.3	97.4
Erythromycin	>2	>2	≤0.06 – >2	14.1	85.9
Azithromycin	>4	>4	≤0.5 – >4	14.3	84.4
Clarithromycin	>32	>32	≤0.25 – >32	14.3	81.8
Clindamycin	1	>2	≤0.25 – >2	46.2	52.6
Levofloxacin	1	1	≤0.5 – >4	94.9	5.1
Trimethoprim/sulfamethoxazole	2	>2	≤0.5 – >2	17.9	50.0
Vancomycin	≤1	≤1	≤1	100.0	-
β-haemolytic streptococci (179)[d]					
Ceftaroline	≤0.008	0.015	≤0.008 – 0.06	-	-
Ceftriaxone	≤0.25	≤0.25	≤0.25	100.0	-
Cefepime	≤0.12	≤0.12	≤0.12 – 0.25	100.0	-
Imipenem	≤0.12	≤0.12	≤0.12	-	-
Penicillin	≤0.015	0.06	≤0.015 – 0.12	100.0	-
Piperacillin/tazobactam	≤0.5	≤0.5	≤0.5	-	-
Erythromycin	≤0.25	>2	≤0.25 – >2	79.3	19.6
Clindamycin	≤0.25	≤0.25	≤0.25 – >2	91.1	8.4
Levofloxacin	≤0.5	1	≤0.5 – 2	100.0	0.0
Trimethoprim/sulfamethoxazole	≤0.5	≤0.5	≤0.5 – >2	-	-
Linezolid	1	1	0.25 – 2	100.0	-
Vancomycin	0.5	0.5	0.25 – 1	100.0	-
Viridans group streptococci (88)[e]					
Ceftaroline	0.015	0.25	≤0.008 – 16	-	-
Ceftriaxone	≤0.25	2	≤0.25 – >32	89.8	5.7
Cefepime	0.25	1	≤0.12 – >16	92.0	4.5
Imipenem	≤0.12	0.25	≤0.12 – >8	-	-
Penicillin	0.06	2	≤0.015 – >32	78.4	8.0
Piperacillin/tazobactam	≤0.5	4	≤0.5 – >64	-	-
Erythromycin	≤0.25	>2	≤0.25 – >2	58.0	36.4
Clindamycin	≤0.25	>2	≤0.25 – >2	88.6	11.4
Levofloxacin	1	1	≤0.5 – >4	97.7	1.1
Trimethoprim/sulfamethoxazole	≤0.5	2	≤0.5 – >2	-	-
Linezolid	1	1	0.12 – 2	100.0	-
Vancomycin	0.5	1	0.25 – 1	100.0	-

a. Criteria as published by the CLSI (2009). - = no breakpoint has been established by the CLSI.

b. Criteria as published by the CLSI (2009) for 'Penicillin parenteral (non-meningitis)'.

c. Criteria as published by the CLSI (2009) for 'Penicillin (oral penicillin V)'.

d. Includes: *Streptococcus dysgalactiae* (7 strains), *Streptococcus equi* (2 strains), Group A *Streptococcus* (75 strains), Group B *Streptococcus* (69 strains), Group C *Streptococcus* (8 strains), and Group G *Streptococcus* (18 strains).

e. Includes: *Streptococcus acidominimus* (1 strain), *Streptococcus anginosus* (12 strains), *Streptococcus constellatus* (9 strains), *Streptococcus gordonii* (1 strain), *Streptococcus intermedius* (4 strains), *Streptococcus milleri* (4 strains), *Streptococcus mitis* (21 strains), *Streptococcus oralis* (6 strains), *Streptococcus salivarius* (9 strains), *Streptococcus sanguinis* (5 strains), and unspecified viridans group streptococci (16 strains).

Table 3. Summary of Ceftaroline Activity Against Organisms from the USA and Europe.

Organism/region (no. tested)	No. of organisms (cumulative %) inhibited at ceftaroline MIC (μg/mL) of: ≤0.008	0.015	0.03	0.06	0.12	0.25	0.5	1
USA								
S. pneumoniae (894)	442 (49.5)	117 (62.5)	53 (68.5)	82 (77.6)	123 (91.4)	66 (98.7)	11 (100.0)	-
Pen.-susceptible (521)	435 (83.5)	64 (95.8)	16 (99.9)	6 (100.0)	-	-	-	-
Pen.-intermediate (178)	7 (3.9)	53 33.7)	36 (53.9)	69 (92.7)	13 (100.0)	-	-	-
Pen.-resistant (195)	-	-	1 (0.5)	7 (4.1)	110 (60.5)	66 (94.4)	11 (100.0)	-
Penicillin MIC ≥8 (9)	-	-	-	-	-	4 (44.4)	5 (100.0)	-
Viridans grp strep. (110)	26 (23.6)	24 (45.5)	37 (79.1)	9 (87.3)	6 (92.7)	3 (95.5)	2 (97.3)	3 (100.0)
β-haemolytic strep. (327)	164 (50.2)	129 (89.6)	33 (99.7)	1 (100.0)	-	-	-	-
Europe								
S. pneumoniae (446)	281 (63.0)	46 (73.3)	20 (77.8)	21 (82.5)	55 (94.8)	22 (99.8)	1 (100.0)	-
Pen.-susceptible (327)	279 (85.3)	39 (97.3)	5 (98.8)	4 (100.0)	-	-	-	-
Pen.-intermediate (41)	2 (4.9)	6 (19.5)	14 (53.7)	14 (87.8)	4 (97.6)	1 (100.0)	-	-
Pen.-resistant (78)	-	1 (1.3)	1 (2.6)	3 (6.4)	51 (71.8)	21 (98.7)	1 (100.0)	-
Viridans grp. strep. (88)	19 (21.6)	25 (50.0)	23 (76.1)	10 (87.5)	1 (88.6)	4 (93.2)	3 (96.6)	2 (98.9)
β-haemolytic strep. (179)	107 (59.8)	60 (93.3)	11 (99.4)	1 (100.0)	-	-	-	-

Conclusions

- Ceftaroline exhibited broad-spectrum activity and high potency against streptococci recently (2008) collected from patients in USA and European medical centers.
- Ceftaroline activity was routinely greater compared with ceftriaxone (8- to 16-fold) and all other antibiotics when tested against *S. pneumoniae* isolates.
- Ceftaroline retains inhibitory activity against *S. pneumoniae* resistant to amoxicillin/clavulanate and/or ceftriaxone.
- Favorable results from in vitro data collected from this surveillance program suggest that ceftaroline is a very promising antimicrobial agent for the treatment of pneumococcal infections.

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