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In vitro susceptibility and distribution of beta-lactamases in Enterobacteriaceae causing intra-abdominal infections in North America 2010–2011☆,☆☆

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ABSTRACT

The Study for Monitoring Antimicrobial Resistance Trends has been monitoring the activity of antimicrobials indicated for the treatment of intra-abdominal infections since 2004. This report documents the in vitro activity of several recommended antimicrobials against 3449 gram-negative bacilli isolated from the 30 and 25 participating sites in North America in 2010–2011, respectively, and characterizes the extended-spectrum beta-lactamases (ESBL) identified in ESBL-positive and ertapenem-non-susceptible isolates of Enterobacteriaceae. *Escherichia coli*, *Klebsiella pneumoniae*, *Enterobacter cloacae*, *Proteus mirabilis*, *Klebsiella oxytoca*, *Citrobacter freundii*, *Enterobacter aerogenes*, *Serratia marcescens*, and *Morganella morgannii* were the most common species isolated. The incidence of beta-lactamase production was 8.8% and 8.9% for *E. coli* and *K. pneumoniae*, respectively. Overall the most active antimicrobials were amikacin, piperacillin-tazobactam, imipenem, and ertapenem, although beta-lactamase production reduced the activity of most agents. Characterization of beta-lactamase genes determined that bla_{SHV}, $bla_{CTX\text{-}M}$, bla_{AmpC}, and bla_{KPC} were commonly found in most beta-lactamase–positive isolates.

1. Introduction

The empiric treatment of intra-abdominal infections (IAI) today is complicated due to the changing epidemiology of pathogens but primarily due to the emergence and evolution of antimicrobial resistance (Cantón et al., 2008; Chen and Hsueh, 2012; Nordmann and Cornaglia, 2012; Pitout and Laupland, 2008; Tzouvelekis et al., 2012). The 2010 Infectious Disease Society of America guidelines indicate either single agent including ertapenem, meropenem, imipenem-cilastatin, tircarcillin-clavulanate, and piperacillin-tazobactam in pediatrics or ciprofloxacin, moxifloxacin, tigecycline, ticarcillin-clavulanate or imipenem-cilastatin, meropenem, doripenem, or piperacillin-tazobactam in adults with mild to moderate or severe high risk in adults or combination therapy using antimicrobials including: carbapenems, extended-spectrum cephalosporins including cefotaxime and ceftazidime beta-lactam/beta-lactamase inhibitors, aminoglycosides, fluoroquinolones, and clindamycin or metronidazole for suspected anaerobes (Solomkin et al., 2010). However, current resistance issues especially in extended-spectrum beta-lactamase (ESBL)–positive, AmpC-positive, or carbapenem-resistant gram-negative bacilli undermine empiric antimicrobial therapy (Pitout and Laupland, 2008). Globally, intra-abdominal pathogens and resistance patterns have been examined in a number of geographic areas (Brink et al., 2012; Cantón et al., 2012; Chen et al., 2011; Hawser et al., 2010, 2011; Kiratisin et al., 2010; Yang et al., 2010). To date, however, less information and guidance on IAI pathogens and their resistance patterns from North America have been published (Hoban et al., 2010). Moreover, limited analysis has been published on the beta-lactamase genes found in Enterobacteriaceae pathogens commonly found in IAI infections. Physicians need to be aware of local epidemiologic and resistance trends and patterns to minimize use of antimicrobials whose efficacy is questionable in the face of increasing resistance. The Study for Monitoring Antimicrobial Resistance Trends (SMART) has been examining the activity of antimicrobials recommended for the treatment of IAIs globally since 2004. This report summarizes the susceptibility patterns and the etiology of ESBLs and carbapenemases: *Klebsiella pneumoniae carbapenemase* (KPC) and New Delhi metallo-beta lactamase (NDM) in Enterobacteriaceae in North America in 2010–2011.

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Table 1
Percent susceptible, resistant, and MIC_{50} and MIC_{90} for the top 10 Enterobacteriaceae intra-abdominal species (N ≥ 20) isolated in North America in 2010–2011.

Isolate/antimicrobial agent	Susceptibility		MIC (μg/mL)		Isolate/antimicrobial agent	Susceptibility		MIC (μg/mL)	
	%S	%R	MIC_{50}	MIC_{90}		%S	%R	MIC_{50}	MIC_{90}
All *E. coli* ($n = 1643$)					*P. mirabilis* ($n = 168$)				
Amikacin	99	0	≤4	8	Amikacin	100	0	≤4	16
Ampicillin-sulbactam	55	27	4	>16	Ampicillin-sulbactam	82	7	≤2	16
Cefepime	93	7	≤0.5	1	Cefepime	98	1	≤0.5	≤0.5
Cefotaxime	89	11	≤0.5	4	Cefotaxime	96	3	≤0.5	≤0.5
Cefoxitin	90	5	4	8	Cefoxitin	98	1	4	8
Ceftazidime	91	9	≤0.5	4	Ceftazidime	98	2	≤0.5	1
Ceftriaxone	89	11	≤1	8	Ceftriaxone	96	4	≤1	≤1
Ciprofloxacin	71	28	≤0.25	>2	Ciprofloxacin	79	19	≤0.25	>2
Ertapenem	100	0	≤0.03	≤0.03	Ertapenem	100	0	≤0.03	≤0.03
Imipenem	100	0	0.12	0.25	Imipenem	20	41	2	4
Levofloxacin	72	27	≤0.5	>4	Levofloxacin	83	11	≤0.5	>4
Piperacillin-tazobactam	94	4	≤2	8	Piperacillin-tazobactam	98	1	≤2	≤2
E. coli, ESBL− ($n = 1507$)					*K. oxytoca* ($n = 165$)				
Amikacin	100	0	≤4	8	Amikacin	99	0	≤4	≤4
Ampicillin-Sulbactam	59	24	≤2	>16	Ampicillin-sulbactam	66	12	8	>16
Cefepime	100	0	≤0.05	≤0.05	Cefepime	98	2	≤0.5	≤0.5
Cefotaxime	96	3	≤0.05	≤0.05	Cefotaxime	94	5	≤0.5	≤0.5
Cefoxitin	91	5	≤2	8	Cefoxitin	96	4	≤2	4
Ceftazidime	97	3	≤0.05	≤0.05	Ceftazidime	98	2	≤0.5	≤0.5
Ceftriaxone	96	3	≤1	≤1	Ceftriaxone	91	8	≤1	≤1
Ciprofloxacin	77	23	≤0.25	>2	Ciprofloxacin	95	4	≤0.25	≤0.25
Ertapenem	100	0	≤0.03	≤0.03	Ertapenem	99	1	≤0.03	≤0.03
Imipenem	100	0	0.12	0.25	Imipenem	98	1	0.25	0.25
Levofloxacin	77	22	≤0.5	>4	Levofloxacin	96	2	≤0.5	≤0.5
Piperacillin-tazobactam	96	3	≤2	4	Piperacillin-tazobactam	91	8	≤2	8
E. coli, ESBL+ ($n = 136$)					*C. freundii* ($n = 126$)				
Amikacin	90	1	≤4	32	Amikacin	100	0	≤4	≤4
Ampicillin-sulbactam	13	64	>16	>16	Ampicillin-sulbactam	49	37	16	>16
Cefepime	13	83	>32	>32	Cefepime	98	2	≤0.5	2
Cefotaxime	2	95	>128	>128	Cefotaxime	69	29	≤0.5	64
Cefoxitin	77	5	4	16	Cefoxitin	4	94	>16	>16
Ceftazidime	24	72	32	128	Ceftazidime	73	27	≤0.5	>128
Ceftriaxone	4	93	>32	>32	Ceftriaxone	69	29	≤1	>32
Ciprofloxacin	13	88	>2	>2	Ciprofloxacin	90	7	≤0.25	2
Ertapenem	97	2	≤0.03	0.25	Ertapenem	98	2	≤0.03	0.25
Imipenem	99	1	0.12	0.25	Imipenem	83	1	1	2
Levofloxacin	15	85	>4	>4	Levofloxacin	93	4	≤0.5	2
Piperacillin-tazobactam	78	14	4	>64	Piperacillin-tazobactam	83	6	≤2	64
All *K. pneumoniae* ($n = 698$)					*S. marcescens* ($n = 109$)				
Amikacin	94	1	≤4	≤4	Amikacin	99	0	≤4	8
Ampicillin-sulbactam	72	18	8	>16	Ampicillin-sulbactam	8	76	>16	>16
Cefepime	91	8	≤0.5	8	Cefepime	97	1	≤0.5	1
Cefotaxime	87	13	≤0.5	32	Cefotaxime	72	18	≤0.5	16
Cefoxitin	86	9	≤2	16	Cefoxitin	25	39	16	>16
Ceftazidime	88	12	≤0.5	64	Ceftazidime	90	8	≤0.5	8
Ceftriaxone	87	13	≤1	>32	Ceftriaxone	84	14	≤1	8
Ciprofloxacin	85	14	≤0.25	>2	Ciprofloxacin	84	10	≤0.25	>2
Ertapenem	94	6	≤0.03	0.12	Ertapenem	98	1	≤0.03	0.25
Imipenem	94	5	0.25	0.5	Imipenem	87	2	1	2
Levofloxacin	87	11	≤0.5	>4	Levofloxacin	94	5	≤0.5	2
Piperacillin-tazobactam	88	10	≤2	64	Piperacillin-tazobactam	87	5	≤2	32
K. pneumoniae, ESBL− ($n = 636$)					*E. aerogenes* ($n = 97$)				
Amikacin	97	0	≤4	≤4	Amikacin	100	0	≤4	≤4
Ampicillin-sulbactam	78	12	8	>16	Ampicillin-sulbactam	29	51	>16	>16
Cefepime	97	3	≤0.5	≤0.5	Cefepime	99	0	≤0.5	1
Cefotaxime	95	4	≤0.5	≤0.5	Cefotaxime	56	41	≤0.5	32
Cefoxitin	89	6	≤2	16	Cefoxitin	5	95	>16	>16
Ceftazidime	96	4	≤0.5	1	Ceftazidime	60	38	≤0.5	64
Ceftriaxone	96	4	≤1	≤1	Ceftriaxone	54	44	≤1	32
Ciprofloxacin	8	91	≤0.25	1	Ciprofloxacin	95	3	≤0.25	≤0.25
Ertapenem	97	3	≤0.03	≤0.03	Ertapenem	95	3	≤0.03	0.5
Imipenem	97	3	0.25	0.5	Imipenem	72	3	1	2
Levofloxacin	93	6	≤0.5	1	Levofloxacin	97	3	≤0.5	≤0.5
Piperacillin-tazobactam	93	5	≤2	16	Piperacillin-tazobactam	70	4	4	64
K. pneumoniae, ESBL+ ($n = 62$)					*M. morganii* ($n = 61$)				
Amikacin	61	3	≤4	32	Amikacin	100	0	≤4	8
Ampicillin-sulbactam	6	79	>16	>16	Ampicillin-sulbactam	3	90	>16	>16
Cefepime	32	56	>32	>32	Cefepime	98	2	≤0.5	≤0.5
Cefotaxime	2	98	>128	>128	Cefotaxime	52	33	1	8
Cefoxitin	53	34	8	>16	Cefoxitin	90	5	8	8
Ceftazidime	6	94	>128	>128	Ceftazidime	80	13	1	16
Ceftriaxone	2	98	>32	>32	Ceftriaxone	79	11	≤1	4
Ciprofloxacin	24	71	>2	>2	Ciprofloxacin	80	13	≤0.25	>2