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***Serratia* infections in a general hospital: characteristics and outcomes**

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31 **Abstract**

32 **Objective** We aimed to present our experience regarding infections caused by *Serratia*
33 spp. in a region with relatively high antimicrobial resistance rates.

34 **Methods** We retrospectively reviewed the databases of the microbiological laboratory
35 of the University hospital of Heraklion, Crete (2/2004-12/2009).

36 **Results** A total of 77 patients [67.5% men, mean age \pm standard deviation (SD)=
37 56.9 \pm 24.5 years) were identified; 37.7% were outpatients. Sixty-five (84.4%) of the 77
38 included patients had a *Serratia marcescens* isolate; the remaining 12 patients had a
39 non-marcescens *Serratia* spp. The most frequently observed infections were respiratory
40 tract infection (32.5%) and keratitis/endophthalmitis (20.8%). Seventy-three (94.9%)
41 patients were cured. Four deaths were observed; 3 of them were considered as attributed
42 to the *Serratia* infection. No difference was found regarding the characteristics and
43 outcomes between patients with *Serratia marcescens* and non-marcescens infections. In
44 addition, antipseudomonal penicillins, as well as their combinations with beta-lactamase
45 inhibitors, carbapenems, and fluoroquinolones exhibited high antimicrobial activity
46 against both the tested *Serratia marcescens* and non-marcescens isolates.

47 **Conclusion** Our study adds useful information regarding the characteristics and
48 outcomes of patients with *Serratia* infection, as well as the susceptibilities of the
49 respective *Serratia marcescens* and non-marcescens isolates, in a region with relatively
50 high levels of antimicrobial resistance.

51

52 **Keywords:** Enterobacteriaceae, *Serratia liquefaciens*, *Serratia rubidaea*, beta-
53 lactamase, nosocomial infection

54

55 **Introduction**

56 *Serratia* spp, particularly *Serratia marcescens*, are mainly encountered as causative
57 pathogens of nosocomial infections and nosocomial outbreaks.^{1,2} Specifically, *Serratia*
58 spp. are incriminated for outbreaks in neonatal intensive care units (NICUs).³⁻⁵ In
59 addition, due to their ability of biofilm formation and the production of enzymes
60 including gelatinase, elastase and alkaline protease, *Serratia* spp. manage to invade
61 human corneal epithelial cells and cause keratitis, and particularly contact lens-related
62 keratitis.^{6,7}

63
64 Even though *Serratia* spp. are mainly considered nosocomial pathogens, recently
65 published population-based studies suggested that a considerable percentage of the
66 identified *Serratia* infections is community-acquired.^{6,8} Even though *Serratia*
67 *marcescens* accounts for the majority of the identified *Serratia* isolates, many reports
68 regarding infections and outbreaks caused from *Serratia* spp. other than *Serratia*
69 *marcescens*, also appeared in the literature.^{7,9-12} In addition, another issue that
70 intensified the importance of *Serratia* infections is the emergence of multi-drug resistant
71 *Serratia* isolates, and particularly extended spectrum beta-lactamase producing *Serratia*
72 isolates (ESBLs).¹³⁻¹⁵

73
74 In this regard, the aim of our study was to present our experience regarding the
75 characteristics and outcomes of patients with infections caused from *Serratia* spp. at a
76 university hospital of a region with relatively high levels of antimicrobial resistance.¹⁶⁻²⁰

78 **Methods**

79 **Study design and patient population**

80 We present a descriptive study, based on the retrospective evaluation of a case series.
81 Specifically, we retrospectively reviewed the databases of the microbiological
82 laboratory of the University hospital of Heraklion, Crete in order to identify patients
83 from whom *Serratia* spp. were isolated, during a 5-year period (February 2004-
84 December 2009). The University hospital of Heraklion, Crete, is a 650-bed tertiary care
85 centre, serving a population of approximately 650.000 individuals, with approximately
86 65.000-70.000 admitted patients/year. The following data were retrieved from the
87 available medical records of the respective patients: sex, age, department of
88 hospitalization, potential risk factors for acquisition of nosocomial infections (including
89 immunosuppression, treatment with corticosteroids, malnutrition, trauma, surgery, and

90 presence of a urinary catheter), type of *Serratia* infection, antibiotic treatment
91 administered for the infection, duration of hospitalization, as well as the outcome of the
92 infection.

93

94 With regard to the evaluated potential risk factors in particular, the objective criteria of
95 malnutrition were a BMI<18.5, or unintentional weight loss of more than 5% in the last
96 month, or more than 10% in the last 6 months, whereas trauma was defined as any
97 injury or wound infection. When more than one *Serratia* isolates were identified from a
98 patient, we selected the 1st isolate for inclusion in our study. Moreover, we retrieved
99 data regarding any other pathogens were simultaneously identified from the same
100 clinical specimen.

101

102 **Microbiological testing**

103 The identification of the isolates was performed with the use of standard biochemical
104 methods, the API 20 E system and the Vitek2 automated system (BioMérieux, Marcy l'
105 Etoile, France).²¹ The antimicrobial susceptibility of the tested isolates to the evaluated
106 antibiotic agents was determined by using the Vitek2 system and the results were
107 interpreted according to CLSI criteria.²²

108

109 **Statistical analysis**

110 We performed comparisons regarding demographic and clinical characteristics between
111 the included patients with a clinical specimen that yielded a *Serratia marcescens* isolate
112 and those with a clinical specimen that yielded a *Serratia* spp. isolate (other than
113 *Serratia marcescens*). The χ^2 test or the Fisher exact tests were used, when appropriate,
114 in the comparisons regarding categorical variables, whereas the t-test was used in the
115 comparisons regarding continuous variables. For non-normally distributed continuous
116 variables, the Mann-Whitney signed-rank test was used. A p value of <0.05 was
117 regarded as indicative of statistical significance. The comparisons were performed with
118 the use of the OpenEpi Software,²³ and the SPSS software version 13.0 (SPSS Inc,
119 Chicago, Illinois, USA).

120

121 **Results**

122 **Patient characteristics**

123 A total of 77 patients were identified as having a clinical specimen that yielded a
124 *Serratia* spp. isolate during the study period. Detailed data regarding the demographic

125 and clinical characteristics of the included patients are presented in Table 1.
126 Specifically, the mean age \pm standard deviation (SD) of the included patients was
127 56.9 \pm 24.5 years. Two of the 77 included patients were infants (7 and 8 months,
128 respectively). The majority (67.5%) of the included patients were men. Regarding the
129 department of hospitalization, the majority (59.7%) of the included patients were
130 admitted in medical wards, whereas a percentage of 37.7% were outpatients. Seventeen
131 (22.1%) of the 77 included patients did not have any comorbidity. Regarding the
132 remaining 60 patients, cardiac diseases were reported most frequently (42.9%). A
133 percentage of 32.5% of the included patients were immunosuppressed, 24.7% were
134 treated with corticosteroids, 19.5% had undergone surgery, 13% had a urinary catheter,
135 9.1% were trauma-patients, and 7.8% were malnourished. In addition, 10 of the
136 evaluated patients were admitted in the ICU; 2 of them on mechanical ventilation. No
137 patient had a central venous catheter.

138

139 **Infections and outcomes**

140 A percentage of 32.5% of the included patients had a respiratory tract infection,
141 followed by a 20.8% that had keratitis/endophthalmitis. None of the latter ocular
142 infections was hospital-acquired. Other types of infections observed were skin and soft
143 tissue infections (16.9%), urinary tract infections (13.0%), sepsis (6.5%), and
144 cholecystitis (3.9%). In addition, 8 (10.4%) of the included patients were considered as
145 colonized with *Serratia* spp. With regard to the patients' outcomes, 73 (94.9%) of the
146 77 included patients were cured. Four deaths were observed during hospitalization in
147 our case series. Three of the 4 deceased patients had monomicrobial *Serratia* infections,
148 whereas the remaining 1 patient had also an infection due to *Citrobacter freundii*. The 4
149 deaths were evaluated by the clinicians that took care of the specific patients as well as
150 the study investigators. Three of these 4 deaths were considered as occurring due to the
151 *Serratia* infection and 1 to other causes.

152

153 **Comparisons regarding patient subpopulations**

154 Comparative data regarding the included patients providing a clinical specimen that
155 yielded a *Serratia marcescens* isolate and those with a clinical specimen that yielded a
156 *Serratia* spp. isolate (other than *Serratia marcescens*) are also presented in Table 1. No
157 difference was found between the compared patient sub-populations regarding the
158 analyzed characteristics and outcomes.

159

160 **Microbiological characteristics**

161 ***Types of isolates and sites of isolation***

162 In Table 2 we present data regarding the isolated *Serratia* spp, the respective sites of
163 isolation, as well as any other simultaneously isolated non-*Serratia* species.

164 Specifically, 65 (84.4%) of the 77 included patients had a *Serratia marcescens* isolate,
165 whereas the remaining 12 patients had a non-marcescens *Serratia* spp. These were:
166 *Serratia liquefaciens* in 5 patients; *Serratia rubidaea*: 3; *Serratia fonticola*: 2; *Serratia*
167 *plymuthica*: 1 and *Serratia ficaria*: 1 patient. Detailed data regarding the respective sites
168 of isolation are presented in Table 2. Other isolates, including *P. aeruginosa*, *K.*
169 *pneumoniae*, and *Candida* spp., were identified concurrently to the isolation of the
170 *Serratia* spp. Detailed data regarding the distribution of the concurrently isolated
171 species are also presented in Table 2.

172

173 ***Antimicrobial susceptibility of the tested isolates***

174 The susceptibility rates of the isolated *Serratia* spp. to the 30 analyzed antimicrobial
175 agents are presented in Table 3. Regarding the isolated *Serratia marcescens*, that
176 constituted the majority [65/77 (84.4 %)] of the identified *Serratia* isolates, the
177 following antibiotic agents exhibited substantial antimicrobial activity against the tested
178 isolates (72%-100% of the tested isolates were found susceptible): antipseudomonal
179 penicillins (specifically, ticarcillin, piperacillin, and ceftazidime), ticarcillin-clavulanic
180 acid, piperacillin-tazobactam, 3rd generation cephalosporins (cefotaxime and
181 ceftriaxone), carbapenems (imipenem and meropenem), aztreonam, tobramycin,
182 netilmicin, nitrofurantoin, and quinolones (specifically, pefloxacin, ofloxacin,
183 norfloxacin, and ciprofloxacin).

184

185 Regarding the 12 tested non-marcescens *Serratia* spp., all of them were found
186 susceptible to the following antimicrobial agents: ticarcillin, piperacillin, ticarcillin-
187 clavulanic acid, piperacillin-tazobactam, ceftazidime, ceftriaxone, cefotaxime,
188 imipenem, meropenem, aztreonam, tobramycin, netilmicin, nitrofurantoin, pefloxacin,
189 ofloxacin, norfloxacin, and ciprofloxacin. In addition, amikacin, gentamicin, and
190 chloramphenicol exhibited substantial antimicrobial activity against the 12 tested
191 isolates (83.3% each).

192

193 **Discussion**

194 A total of 77 patients providing a clinical specimen that yielded a *Serratia* spp. isolate,
195 were identified in a 700-bed tertiary care hospital during a 5-year period. The majority
196 of the *Serratia* isolates were identified in male patients. This observation is in
197 accordance with the findings of recent population-based studies, in which males were
198 considered to be at higher risk for the acquisition of a *Serratia* isolate.⁸ In addition, ICU
199 patients were represented by rather low percentages (13%) in this cohort, whereas a
200 considerable percentage (38%) of the included patients were outpatients. Indeed,
201 population-based studies also reported that the majority of the isolated *Serratia* species,⁸
202 including a considerable percentage of *Serratia* bacteremic episodes were of community
203 onset.²⁴

204
205 With regard to the observed *Serratia* infections, these were mostly respiratory tract
206 infections, followed by ocular infections, including keratitis and/or endophthalmitis,
207 skin and soft tissue infections, and urinary tract infections. Indeed, due to their ability
208 for biofilm formation, based on the interaction of quorum sensing system and nutrient
209 factors,^{25,26} *Serratia* spp frequently colonize medical devices, such as bronchoscopes,²⁷
210 urinary catheters,²⁸ water supplies,²⁹ whereas long-term carriage in the hands of
211 healthcare workers has been reported, as well.³⁰ Consequently, *Serratia* spp are
212 frequently incriminated for hospital-acquired bacteremias nosocomial respiratory and
213 urinary tract infections, and nosocomial outbreaks.³¹⁻³⁴ Specifically, 13% of the
214 included patients had a urinary catheter. In addition, due to the production of specific
215 enzymes such as gelatinase, elastase and alkaline protease, *Serratia* spp. cause ocular
216 infections including ulcerative keratitis, particularly contact lens-related keratitis,^{6,35}
217 and endophthalmitis.^{36,37} Moreover, immunocompromised patients are considered more
218 prone to *Serratia* infections. Of note, a considerable percentage of 32.5% of the
219 included patients were immunosuppressed, and an additional 24.7% received
220 corticosteroids.

221
222 *Serratia marcescens* is the most frequently isolated *Serratia* spp. However, other
223 *Serratia* spp. including *Serratia liquefaciens*, *Serratia plymuthica*, and *Serratia*
224 *rubidaea*, are recently identified as the cause of *Serratia* nosocomial infections and
225 outbreaks.^{10, 12, 38, 39} Furthermore, non-marcescens *Serratia* spp are also incriminated for
226 community-acquired infections.⁴⁰ A possible explanation that has been proposed for the
227 relative scarcity of published evidence regarding non-marcescens *Serratia* spp.
228 compared to *Serratia marcescens* is the misidentification of these specific strains by

229 commercially available identification systems.⁴¹ In our study, 12 (15.5%) of the 77
230 included patients provided a clinical specimen that non-marcescens *Serratia* spp
231 (specifically, *Serratia liquefaciens*, *Serratia rubidaea*, *Serratia fonticola*, *Serratia*
232 *plymuthica*, and *Serratia ficaria*). The majority of the respective infections were
233 respiratory tract infections. Its worth to note that in the comparisons between the patient
234 subpopulations with *S. marcescens* infection and those with non-marcescens *Serratia*
235 infection, no difference was found regarding the demographical characteristics,
236 comorbidity, risk-factors, types of infections, as well as infection outcomes.

237

238 As far as mortality is concerned, 4 of the 77 included patients died. Three of these 4
239 deaths were considered to have been probably attributed to the *Serratia* infection, after a
240 meticulous evaluation of the respective clinical data from the clinicians as well as the
241 study investigators. Regarding mortality from *Serratia* infections, published evidence
242 report percentages of 5% and 37% for *Serratia* bacteremia 7-day and 6-months
243 mortality, respectively.²⁴ However, mortality can occur even in less severe *Serratia*
244 infections, such as urinary tract infections. Specifically, female gender and the
245 development of secondary *S. marcescens* bacteremia have been identified as risk factors
246 independently associated with fatality in patients with urinary tract infection due to *S.*
247 *marcescens*.⁴² Moreover, the emergence of ESBL-producing *Serratia* spp. intensifies
248 the importance of the issue of *Serratia* infection-related mortality. Specifically, a 30-day
249 mortality rate of 33% has been reported for nosocomial patients with ESBL-producing
250 *S. marcescens* infections.⁴³

251

252 *Serratia* spp. exhibit considerable antimicrobial resistance to penicillins and
253 cephalosporins. This is mainly attributed to the fact that AmpC beta-lactamases are
254 encoded in the chromosome of *Serratia* spp. The expression of these genes is inducible
255 in most cases.^{44, 45} In our study all the 65 tested *Serratia marcescens* isolates were found
256 resistant to amoxicillin and amoxicillin/clavulanic acid. Similarly, 1 of the 12 non-
257 marcescens *Serratia* spp was susceptible to the above drugs. This observation was
258 consistent regarding cefalothin, a 1st generation cephalosporin, whereas regarding
259 cefuroxime, lower susceptibility rates were observed for the tested *Serratia marcescens*
260 compared to the non-marcescens isolates. Additionally, a 35% of the tested *Serratia*
261 *marcescens* isolates and a 50% of the non-marcescens isolates were found susceptible to
262 ceftazidime and cefotaxime) and

263 ceftriaxone exhibited high susceptibility rates regarding the *Serratia marcescens* and
264 non-marcescens tested isolates (95.4% and 100%, respectively).

265

266 On the other, other beta-lactamases, including CTX-M3, IMP-type, as well as TEM-
267 type have also been identified in *Serratia* spp.^{14, 46-48} Specifically, the issue of the
268 emergence of carbapenem resistance *Serratia* strains is of major importance. In our
269 study, both imipenem and meropenem exhibited high antimicrobial activity rates against
270 the tested *Serratia marcescens* and non-marcescens isolates. In addition, among the
271 evaluated antimicrobial agents, tobramycin, netilmicin, nitrofurantoin, as well as the
272 combination of trimethoprim with sulfonamides were also found highly active against
273 the tested *Serratia marcescens* and non-marcescens isolates. On the contrary, amikacin
274 and gentamicin were found to be more active against the tested non-marcescens isolates
275 (83%) compared to the tested *Serratia marcescens* isolates. Finally, fluoroquinolones
276 were also highly active against the tested *Serratia marcescens* and non-marcescens
277 isolates. However, evidence regarding the chromosome-encoded resistance to
278 fluoroquinolones of *Serratia marcescens* has appeared in the literature.⁴⁹⁻⁵¹

279

280 Our study has specific limitations that should be considered. Firstly, **one should bear in**
281 **mind the intrinsic methodological limitations of retrospective cohort studies before the**
282 **extrapolation of the study findings. In addition,** our findings derive from the evaluation
283 of the clinical and microbiological data of a rather limited number of 77 patients that
284 provided a clinical specimen that yielded a *Serratia* spp. isolate. Moreover, since
285 *Serratia* spp. are often incriminated for nosocomial epidemics, one may consider that
286 the *Serratia* strains included in this study are epidemic strains. Yet, even though genetic
287 identification techniques were not used in this study, the 5-year study period is rather
288 contradictory to the potential of a concurrent nosocomial epidemic. **However, one may**
289 **consider that a proportion of the tested *Serratia* isolates might have been of the same**
290 **clonal origin.** Finally, even though the emergence of ESBL-producing *Serratia* spp.
291 appears to be an issue of increasing importance, microbiological methods for the
292 identification of ESBL-producing isolates, among the evaluated *Serratia* isolates, were
293 also not implemented in this study.

294

295 In conclusion, our study aids in the clarification of issues regarding the characteristics
296 and outcomes of patients with *Serratia* infections, as well as regarding the susceptibility
297 patterns of the respective isolates. In the era of alarmingly high antimicrobial resistance,

298 and particularly in the era of ESBL-producing enterobacteriaceae,⁵² our findings may
299 provide useful information regarding the infections caused from this specific pathogen,
300 as they derive from a clinical setting with relatively high levels of antimicrobial
301 resistance.

302

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Table 1. Baseline characteristics, infections and outcomes of the included patients.

	Mean (\pm SD) or number (%)			P value (Group A vs Group B)
	All n ₁ =77	<i>Serratia</i> <i>marcescens</i> (Group A) n ₂ =65	Other <i>Serratia</i> spp. (non-marcescens) (Group B) n ₃ =12	
Number of patients				
Demographics				
Age (years)	56.9 \pm 24.5	56.3 \pm 24.5	59.9 \pm 25.9	0.7
Sex (male)	52 (67.5)	45 (69.2)	7 (58.3)	0.7
Department of hospitalization				
Medical	46 (59.7)	38(58.5)	8 (66.7)	0.8
Surgical	13 (16.9)	11 (16.9)	2 (16.7)	>0.9
Pediatric	2 (2.9)	2 (3.1)	0	>0.9
ICU	10 (13.0)	10 (15.4)	0	0.3
Outpatients	29 (37.7)	25 (38.5)	4 (33.3)	>0.9
Transfer from another hospital	2 (2.9)	2 (3.1)	0 (0)	>0.9
Comorbidity				
None	17 (22.1)	13 (20.0)	4 (33.3)	0.5
Diabetes mellitus	12 (15.6)	9 (13.8)	3 (25.0)	0.6
Cardiac diseases	33 (42.9)	27 (41.5)	6 (50.0)	0.8
Pulmonary diseases	14 (18.2)	12 (18.5)	2 (16.7)	>0.9
Renal diseases	7 (9.1)	5 (7.7)	2 (16.7)	0.6
Hepatic diseases	2 (2.6)	2 (3.1)	0	>0.9
CNS diseases	11(14.3)	11 (16.9)	0	0.3
Orthopedic diseases	9 (11.7)	8 (12.3)	1 (8.3)	>0.9
Malignancies	14 (18.2)	11 (16.9)	3 (25.0)	0.8
Autoimmune diseases	6 (7.8)	4 (6.2)	2 (16.7)	0.5
Hyperuricaemia	3 (3.9)	2 (3.1)	1 (8.3)	0.8
Smoking	11 (14.3)	10 (15.4)	1 (8.3)	0.9
Bening prostate hyperplasia	5 (6.5)	4 (6.2)	1 (8.3)	>0.9
Lipofuscinosis	1 (1.3)	1 (1.5)	0	>0.9
Risk factors				
Corticosteroids	19 (24.7)	16 (24.6)	3 (25.0)	>0.9
Immunosuppression	25 (32.5)	19 (29.2)	6 (50.0)	0.3
Malnutrition	6 (7.8)	3 (4.6)	3 (25.0)	0.1
Urinary catheter	10 (13.0)	8 (12.3)	2 (16.7)	>0.9
Trauma	7 (9.1)	6 (9.3)	1 (8.3)	>0.9
Surgery	15 (19.5)	13 (20.0)	2 (16.7)	>0.9
Type of infection				
RTI	25 (32.5)	20 (30.8)	5 (41.7)	0.7
UTI	10 (13.0)	10 (15.4)	0	0.3
SSTI	13 (16.9)	9 (13.9)	4 (33.3)	0.2
Keratitis/endophthal mitis	16 (20.8)	14 (21.5)	2 (16.7)	>0.9
Cholecystitis	3 (3.9)	2 (3.1)	1 (8.3)	0.8
Sepsis	5 (6.5)	4 (6.2)	1 (8.3)	>0.9
Colonization	8 (10.4)	8(12.3)	0	0.5
Time to acquisition of the 1st positive culture for <i>Serratia</i> spp.	Median (range) [*] : 2 (0-158)	Median (range) ^{**} : 2 (0-158)	Median (range) ^{***} : 2 (0-5)	0.4
Duration of hospitalization (days)	Median (range) [*] : 6 (1-206)	Median (range) ^{**} : 7 (1-206)	Median (range) ^{***} : 5 (1-15)	0.3

Outcome				
Cure	73 (94.9)	61 (93.8)	12 (100)	0.9
Death	4 (5.2)	4 (6.2)	0 (0)	>0.9

455 Abbreviations: ICU: intensive care unit, CNS: central nervous system, RTI: respiratory tract infection, UTI:

456 urinary tract infections, SSTI: skin and soft tissue infection.

457*: NR: 15/77 (19.2%)

458**: NR: 12/65 (18.1%)

459***: NR: 3/12 (25%)

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Table 2. Data regarding the isolated species and sites of isolation.

Species identified

Serratia spp.

<i>Serratia marcescens</i>	65 (84.4)
<i>Serratia liquefaciens</i>	5 (6.5)
<i>Serratia rubidaea</i>	3 (3.9)
<i>Serratia fonticola</i>	2 (2.6)
<i>Serratia plymuthica</i>	1 (1.3)
<i>Serratia ficaria</i>	1 (1.3)

Other species

<i>Staphylococcus spp.</i>	3 (3.9)
<i>Proteus vulgaris</i>	1 (1.3)
<i>Pseudomonas aeruginosa</i>	4 (5.2)
<i>Klebsiella pneumoniae</i>	1 (1.3)
<i>Candida spp</i>	2 (2.6)
<i>Escherichia coli</i>	1 (1.3)
<i>Enterococcus faecalis</i>	1 (1.3)
<i>Mycoplasma pneumoniae</i>	1 (1.3)
<i>Enterococcus faecalis</i>	1 (1.3)
<i>Citrobacter freundii</i>	1 (1.3)

Site of isolation

Blood	6 (7.8)
Urine	12 (15.6)
BAL	9 (11.7)
Bronchial secretions	8 (10.4)
Pharyngeal aspirate	3 (3.9)
Nasal aspirate	1 (1.3)
Sputum	7 (9.1)
Pus	13 (16.8)
Contact lens	9 (11.7)
Bile	3 (3.8)
Ocular aspirate	6 (7.8)
Conjunctiva	1 (1.3)
Yaloid pus	1 (1.3)
Tracheal tube	1 (1.3)

Number of positive cultures

One	70 (90.9)
Two	7 (9.1)

462 Abbreviations: BAL: bronchoalveolar lavage.

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Table 3. Susceptibility patterns of *Serratia* isolates tested.

Antimicrobial agents	<i>Serratia marcescens</i> n ₁ =65		<i>Serratia</i> spp. (non-marcescens)* n ₂ =12		All <i>Serratia</i> isolates tested n=77	
	S (%)	I (%)	S (%)	I (%)	S (%)	I (%)
Ampicillin	0	0	1 (8.3)	0	1 (1.2)	0
Amoxicillin+Clavulanic acid	0	0	1 (8.3)	0	1 (1.2)	0
Ticarcillin	59 (90.8)	0	12 (100)	0	71 (92.2)	0
Ticarcillin+Clavulanic acid	61 (93.8)	1(1.5)	12 (100)	0	73 (94.8)	1 (1.2)
Piperacillin	60 (92.3)	2 (3.1)	12 (100)	0	72 (96.0)	2 (2.5)
Piperacillin/tazobactam	62 (95.4)	0	12 (100)	0	74 (98.6)	0
Cefalothin	0	0	1 (8.3)	0	1 (1.2)	0
Cefuroxime	2 (3.1)	1 (1.5)	3 (25.0)	0	5 (6.4)	1 (1.2)
Cefoxitin	23 (35.4)	29 (44.6)	6 (50.0)	2 (16.7)	30 (38.9)	31 (40.2)
Cefotaxime	62 (95.4)	0	12 (100)	0	74 (98.6)	0
Ceftriaxone	62 (95.4)	0	12 (100)	0	74 (98.6)	0
Ceftazidime	62 (95.4)	0	12 (100)	0	74 (98.6)	0
Imipenem	62 (95.4)	0	12 (100)	0	74 (98.6)	0
Meropenem	64 (98.4)	0	12 (100)	0	76 (98.7)	0
Aztreonam	65 (100)	0	12 (100)	0	77 (100)	0
Tobramycin	60 (92.3)	2 (3.1)	12 (100)	0	72 (93.5)	2 (2.5)
Amikacin	34 (52.3)	5 (7.7)	10 (83.3)	0	44 (57.1)	5 (6.4)
Gentamicin	35 (53.8)	4 (6.2)	10 (83.3)	0	45 (58.4)	4 (5.1)
Netilmicin	58 (89.2)	2 (3.1)	12 (100)	0	71 (92.2)	2 (2.5)
Chloramphenicol	30/61 (49.2)**	5 (8.21)	10 (83.3)	0	40/73 (54.7)	5/73 (6.8)
Tetracycline	17/25 (68.0)***	3 (12.0)	3/3#	0	21/28 (75)	3/28 (10.7)
Trimethoprim	4 (6.2)	0	1 (8.3)	0	5 (6.4)	0
Trimethoprim+Sulfonamides	63 (96.9)	1 (1.5)	12 (100)	0	75 (97.4)	1 (1.2)
Nitrofurantoin	59 (90.7)	0	12 (100)	0	71 (92.2)	0
Nalidixic acid	4 (6.2)	1 (1.5)	1 (8.3)	2 (16.7)	5 (6.4)	3 (3.8)
Pefloxacin	60 (92.3)	0	12 (100)	0	72 (93.5)	0
Ofloxacin	62 (95.4)	1 (1.5)	12 (100)	0	74 (96.1)	1 (1.2)
Norfloxacin	63 (96.9)	0	12 (100)	0	75 (97.4)	0
Ciprofloxacin	63 (96.9)	0	12 (100)	0	75 (97.4)	0

Abbreviations: S: susceptibility, I: intermediate susceptibility, NR: Not Reported.

*: These include: *Serratia liquefaciens*: 5, *Serratia rubidaea*: 3, *Serratia fonticola*: 2, *Serratia plymuthica*: 1, *Serratia ficaria*: 1.

** : NR: 4/66 (6.1%)

***: NR: 40/66 (60.6%)

#: NR: 9/12 (75.0%)