# Nosocomial Infection in the Community Hospital: Severe Infection Due to *Serratia* Species

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*Background.* *Serratia* bacteremia is an uncommon illness in hospitalized patients. The aim of this study was to determine how frequently this disease occurs nosocomially and to discover the most common portals of entry and the underlying disorders.

*Methods.* Fifty-six cases of *Serratia* bacteremia documented by blood culture (17 cases over a 4-year period in a community hospital in Gainesville, Florida, and 39 cases over a 3-year period in three community hospitals in Dayton, Ohio) were reviewed. Comparison was made with 60 control cases of general bacteremia from three Dayton hospitals.

*Results.* Of the 56 study cases of *Serratia* bacteremia, 45 (80.4%) were classified as nosocomial, compared with 13 (21.7%) of the controls. Twenty-seven (48.2%) of the 56 *Serratia* cases occurred in intensive care units. The cases were evenly distributed over the two study periods, and no outbreaks on specific units were noted. The most common portals of entry for *Serratia* organisms were, in descending order, lung, genitourinary tract, unknown, intravenous line, gastrointestinal tract, and skin. The most common underlying disorder for *Serratia* bacteremia was malignancy, followed by renal failure (acute or chronic) and diabetes mellitus. Most of the *Serratia* organisms tested were sensitive to carbenicillin, trimethoprim/sulfamethoxazole, ceftizoxime, ceftriaxone, ceftazidime, cefotetan, aztreonam, ticarcillin/clavulanate, and ciprofloxacin. The organisms were largely resistant to ampicillin, tetracycline, cefazolin, cephalothin, and cefuroxime. Twenty-five percent of the patients with *Serratia* bacteremia died, compared with 13.6% of the bacteremic controls.

*Conclusions.* *Serratia* bacteremia is often acquired nosocomially. The mortality rate among the study population was surprisingly low for this opportunistic bacteremia, but was higher (though not significantly so) than that of the controls.

*Key words.* *Serratia*; bacteremia; cross infection; community hospitals. ( *J Fam Pract 1996; 42:273-277*)

Bacteria of the genus *Serratia* commonly cause opportunistic infections that are considered to be of nosocomial origin.[1,2] The organism has now been implicated as a causative agent in many kinds of infections, including meningitis, otitis media, peritonitis, endocarditis; infections of the respiratory and urinary tract; and infections of the musculoskeletal system, wounds, eyes, lymph glands, and skin.[2] Outbreaks of infection due to these organisms on various hospital wards and specialty care units have been described in the literature.[3,4] Many of these outbreaks have been traced to colonization of the organism on unit equipment, such as faucets or pressure transducers.[2,5] *Serratia* organisms thrive in moist environments, including medicated solutions, which may facilitate rapid dispersal of the organism within the hospital.[2] The predominant mode of spread, however, appears to be hand-to-hand transmission by hospital personnel.[2]

Before 1968, only 15 cases of *Serratia* bacteremia

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had been recorded in the medical literature,[2] but many cases have been recorded in hospitals since then. Only a very few reports, however, deal specifically with the activity of this organism in the community hospital, and no such studies include a control group.

This article describes 56 cases occurring in four community hospitals, one in Gainesville, Florida, and three in Dayton, Ohio, and compares them with 60 control cases of general bacteremia. A MEDLINE search produced only one study[6] of *Serratia* bacteremia with a larger sample than that of the current study. While cases of *Serratia* bacteremia are not commonly seen by family physicians, nosocomial bacteremia is frequently seen by family physicians in both nursing homes and hospitals. *Serratia* bacteremia is a prototype nosocomial infection.

## Methods

Between July 1982 and June 1986, blood culture reports from the microbiology laboratory at a 453-bed acute care general hospital serving Gainesville, Florida, and the surrounding rural areas were reviewed to elicit blood cultures positive for *Serratia* species. Between April 1988 and June 1991, blood culture reports were also reviewed at three community hospitals in Dayton, Ohio. All cases found during these periods were used for the study. For controls, cases of bacteremia that occurred between August 1988 and November 1992 and were documented by positive blood culture were taken from three Dayton hospitals, two of which were institutions where some of the study cases occurred. Control cases were taken in series to be consistent with the study data collection method. Blood cultures that were positive for *Staphylococcus epidermidis*, diphtheroids, or *Bacillus* species were excluded from the control data as probable contaminants.

Data on all cases of bacteremia were then taken from patient charts. Blood cultures were drawn and microorganisms were identified by standard laboratory methods.[7] The organism was considered nosocomial if it was isolated after 48 hours following the patient's admission. It was considered community-acquired if it was isolated when the patient had been in the hospital less than 48 hours.[8] Fever was defined as a temperature greater than or equal to 100.5°F at any time in the 24-hour period preceding the drawing of the positive blood culture. Leukocyte counts were examined in the period 24 hours before and after the drawing of the positive blood culture. Normal ranges for leukocyte counts were defined by the individual hospital.

The portal of entry of the organism was defined as the site through which the organism gained access to the blood stream, as judged on the basis of all clinical data. For example, if 100,000 colonies of *Serratia marcescens* with the same antibiotic susceptibility pattern was cultured from the urine at the same time as from the blood, the portal of entry would be considered genitourinary. If the same *Serratia* strain as in the blood was cultured from a site on the integument, the portal of entry would be listed as skin. Unfortunately, a culture from the presumed site of entry was not always obtained. If, for example, the patient had a radiologically proven pneumonia at the same time as bacteremia, the portal of entry was listed as lung. The portal of entry was listed as gastrointestinal if the patient had had a recent gastrointestinal event, such as an advanced neoplasm or recent extensive gastrointestinal surgery and there was no other potential portal of entry for the organism. Often, owing to a lack of clinical data, the portal of entry was listed as unknown.

The underlying disorder was defined as the illness the patient might have that would predispose him or her to severe infection, eg, malignancy or diabetes mellitus.[9,10] If no underlying disorder for the patient's bacteremia could be found, it was listed as "none determined." Malignancy was considered an underlying disorder only if it was advanced or was associated with distant metastases.

Appropriate treatment for study purposes was defined as any bactericidal antibiotic to which the organism was susceptible that was given intravenously in a high dose at the onset of bacteremia, as determined by the positive blood culture, and for at least 3 days thereafter. Antibiotic sensitivities for the *Serratia* species were performed according to the method of Bauer and Kirby for some isolates[11] and by minimal inhibitory concentrations for others. For purposes of this study, minimal inhibitory concentration values were converted to designations of sensitive, resistant, or of intermediate sensitivity to the antibiotic, as determined by laboratory evaluation to be consistent with the Bauer-Kirby designations.

## Results

Fifty-six cases of *Serratia* bacteremia were elicited from the study institutions: 17 cases from the Florida hospital, and 23, 9, and 7 from the three Ohio institutions. There were 228,771 admissions to the three Ohio hospitals during the study period, for a rate of 0.17 cases per 1000 admissions for *Serratia* bacteremia. The total number of admissions to the Florida hospital during the respective study period was not available. Sixty control cases of bacteremia were obtained. The most common infecting organism in the control cases was *Escherichia coli* (22 cases) followed by *Staphylococcus aureus* (10 cases), *Klebsiella*

Table 1. Clinical Factors Among Patients with *Serratia* Bacteremia and Those in the Control Group

| Clinical Factors | *Serratia*, % (n=56) | Control,*% (n=60) |
|---|---|---|
| Febrile status† | | |
| Fever | 42.9 | 53.3 |
| No fever | 44.6 | 43.4 |
| Not recorded | 12.5 | 3.3 |
| Leukocyte count† | | |
| High | 64.3 | 63.3 |
| Normal | 19.6 | 20.0 |
| Low | 12.5 | 10.0 |
| Not performed | 3.6 | 6.7 |

**Organisms in the control group included* Escherichia coli *(22)*, Staphylococcus aureus *(10)*, Klebsiella pneumoniae *(7)*, Streptococcus pneumoniae *(5)*, Enterococcus faecalis *(3), and others (13).*
†*P=NS.*

*pneumoniae* (7 cases), *Streptococcus pneumoniae* (5 cases), *Enterococcus faecalis* (3 cases), and others (13 cases).*

There were 52 cases with *Serratia marcescens*, three with *Serratia rubidaea* (all at the Florida hospital), and one case with an unidentified *Serratia* species. Of the cases of *Serratia* bacteremia, no clusters of cases in individual hospital units were noted during this time. Three of the *Serratia* isolates were in a mixed culture. Two of these were in culture with an *Enterococcus* species, and one was in culture with a microaerophilic streptococcus. Forty-five (80.4%) cases of *Serratia* bacteremia were classified as nosocomial, compared with 13 (21.6%) of the controls ($\chi^2$=34.089, $P<.001$). Eleven (19.6%) of the *Serratia* cases were community-acquired, compared with 40 (66.7%) of the controls, seven of which were of unknown cause. Approximately one half of the cultures positive for *Serratia* species were drawn in intensive care units, and the remaining half were from medical-surgical floors. The average age of patients with *Serratia* bacteremia was 60.1 years, with a range of newborn to 87 years. For the control group, the average age was 69.9 years, with a range of 36 to 100 years.

A significantly larger proportion of men (n=36, 64.3%) than women (n=20, 35.7%) acquired *Serratia* bacteremia ($\chi^2$=4.342, $P$=.04), compared with 27 (45.0%) men and 33 (55.0%) women in the control group. An examination of clinical factors (Table 1) revealed that neither fever nor leukocyte counts differed significantly between the *Serratia* and control groups. The most common portals of entry for *Serratia* bacteremia were lung (n=22, 39.3%), genitourinary (n=13, 23.2%), unknown (n=9, 16.1%), intravenous catheter (n=4, 7.1%), gastrointestinal (n=3, 5.4%), skin (n=3, 5.4%), dialysis fistula (n=1, 1.8%), and peritoneum via intraperitoneal abscess (n=1, 1.8%). There is significant evidence that the lung was the portal of entry in more of the study cases than controls, and there is some evidence that the genitourinary tract was the portal of entry in more of the controls than study cases ($\chi^2$=14.084, $P$=.003).

The most common underlying disorder for *Serratia* bacteremia was advanced malignancy (n=11, 19.6%), followed by acute or chronic renal failure (n=7, 12.5%), diabetes mellitus (n=6, 10.7%), chronic obstructive pulmonary disease (n=4, 7.1%), and postoperative cardiovascular surgery (n=4, 7.1%). In 15 (25.0%) of the controls, no underlying disorder was detected. The most frequently identified disorders in the controls were diabetes mellitus (n=13, 21.7%), advanced malignancy (n=6, 10%), and severe post-cerebrovascular accident (n=4, 6.6%).* Thirteen (23.2%) of the patients with *Serratia* bacteremia died, compared with eight (13.4%) of the controls. There were five cases of shock and two cases of disseminated intravascular coagulation associated with the *Serratia* bacteremia. No cases of pyogenic metastatic foci were noted for the latter.

Antibiotics that exhibited high sensitivities for the organisms (>80% of the organisms sensitive) were carbenicillin, trimethoprim/sulfamethoxazole, ceftriaxone, ceftazidime, ceftizoxime, cefotetan, amikacin, ciprofloxacin, aztreonam, and ticarcillin/clavulanate (Table 2). Antibiotics that exhibited low sensitivities for the organisms (<20% of the organisms sensitive) were ampicillin, tetracycline, cefazolin, cephalothin, cefuroxime, and ampicillin/sulbactam. The sensitivity rates for tobramycin and gentamicin were 61.6% and 72.0%, respectively.

Table 3 presents a summary of survival rates in the two groups broken down by the appropriateness of antibiotic therapy. Because of insufficient clinical data, appropriateness of therapy could not be determined for two patients in the *Serratia* group and one patient in the control group. Although sample sizes were too small to detect any significant differences, survival rates were somewhat higher in the control group than in the *Serratia* group, regardless of the appropriateness of the therapy. Furthermore, survival rates in the *Serratia* group appeared slightly, though not significantly, higher if treatment was appropriate.

## Discussion

The rate of *Serratia* bacteremia was 0.17 per 1000 admissions in the three Ohio hospitals compared with 0.18,[12] 0.52,[13] and 1.24[14] per 1000 in other series. This study

**An exact listing of control organisms may be obtained from the authors.*

**A full listing of underlying disorders may be obtained from the authors.*

Table 2. Antibiotic Sensitivity Patterns for Community Hospital *Serratia* Isolates

| Drug Therapy | No. Performed | Sensitive, % | Intermediate, % | Resistant, % |
|---|---|---|---|---|
| Carbenicillin | 13 | 84.6 | | 15.4 |
| Ampicillin | 49 | 6.1 | | 93.9 |
| Tetracycline | 29 | 20.7 | 6.9 | 72.4 |
| Mezlocillin | 33 | 75.8 | | 24.2 |
| Cefazolin | 40 | 0 | | 100 |
| Cephalothin | 7 | 0 | | 100 |
| Cefoxitin | 15 | 46.7 | 26.7 | 26.7 |
| Tobramycin | 39 | 61.5 | 5.1 | 33.3 |
| Gentamicin | 50 | 72.0 | | 28.0 |
| Trimethoprim/ sulfamethoxazole | 39 | 92.3 | | 7.7 |
| Piperacillin | 23 | 73.9 | | 26.1 |
| Ticarcillin | 3 | 100 | | 0 |
| Cefuroxime | 28 | 3.6 | 3.6 | 92.9 |
| Ceftriaxone | 30 | 96.7 | | 3.3 |
| Ceftazidime | 10 | 90 | | 10 |
| Ampicillin/ sulbactam | 23 | 21.7 | | 78.3 |
| Amikacin | 16 | 93.8 | | 6.3 |
| Ceftizoxime | 21 | 95.2 | | 4.8 |
| Ciprofloxacin | 26 | 92.3 | | 7.7 |
| Cefotetan | 21 | 95.2 | | 4.8 |
| Aztreonam | 17 | 82.4 | | 17.6 |
| Timentin | 17 | 88.2 | | 11.8 |
| Penicillin | 1 | 0 | | 100 |
| Imipenem-cilastatin | 2 | 100 | | 0 |
| Cefamandole | 3 | 0 | | 100 |

affirms that infection caused by *Serratia* bacteremia is significantly more likely to be nosocomial in origin: 80.4% of the organisms in this study met criteria for being nosocomial, compared with 21.6% in the control group. Other studies report 92%,[14] 70%,[12] and 74%[13] of *Serratia* bacteremia as being nosocomially acquired. Unlike other studies, there did not appear to be any outbreaks of infection with these organisms in a short period of time in any one area of the hospital.[2–5] As is commonly reported, about one half of the *Serratia* organisms were isolated on intensive care units.[3,5] The reason for the preponderance of men in the *Serratia* group compared with controls is unknown. However, this strong predilection for men was also reported in three other studies.[6,13,14] As with other forms of bacteremia,[9] this study affirms that patients bacteremic with a *Serratia* species do not necessarily have fever at onset of infection nor do they necessarily have a high leukocyte count.[9,10]

Table 3. Mortality Rates Among *Serratia* Bacteremia and Control Group Patients Receiving Appropriate or Inappropriate Antibiotic Therapy

| Therapy | Patients with *Serratia* Bacteremia | | Patients in Control Group | |
|---|---|---|---|---|
| | Total No. | % Died | Total No. | % Died |
| Appropriate | 45 | 22.2 | 44 | 13.6 |
| Inappropriate | 9 | 33.3 | 15 | 13.3 |

*NOTE: Data were analyzed as a three-way contingency table using a log-linear model. No effects were significant.*

The reason significantly more *Serratia* organisms appeared to enter the blood stream through the lung, while bacteria among the controls were more likely to have entered through the genitourinary tract, may be that over one third of the organisms in the control group were *Escherichia coli*, which would have a predilection for the urinary tract. In this study, the most common portals of entry for *Serratia* were, in descending order, lung, genitourinary, and unknown, compared with the order reported in other studies: unknown, lower respiratory, and urinary tract[12]; urinary and lower respiratory tract and surgical wound[14]; and unknown, urinary tract, and lung.[13] Three cases in this study were felt to have a gastrointestinal portal of entry, and intestinal colonization as a predisposition to infection has been referred to elsewhere.[2,3] Entry of the organism into the blood stream was traced directly to an intravenous line in only four cases, and in one case, it was traced to a dialysis arteriovenous fistula.

We do not know why the most common underlying disorder among patients with *Serratia* bacteremia was malignancy, while diabetes mellitus was the most common underlying disorder in the control group. However, altered immune states coexisting with malignancy as well as chemotherapy certainly could predispose a patient to *Serratia* bacteremia.[9] Not surprisingly, most of the *Serratia* bacteremia patients were already severely ill, some with multiple medical problems, as one might expect to see opportunistic infection in seriously ill patients. The most common underlying disorders among patients with *Serratia* bacteremia were, in descending order, advanced malignancy, renal failure, and diabetes mellitus. Other studies report obstructive pulmonary disease, neoplasia, and renal lithiasis[14]; cardiac disease, diabetes mellitus, and severe renal failure[12]; and disturbed consciousness, surgery, and malignancy.[13] Unlike another study,[14] two cases of concurring disseminated intravascular coagulation were noted in the current study.

The *Serratia* organisms appeared to be very susceptible to third-generation cephalosporins, trimethoprim/sulfamethoxazole, amikacin, ciprofloxacin, aztreonam, and ticarcillin/clavulanate. Susceptibility rates to gentamicin and tobramycin (72.0% and 61.6%, respectively), two antibiotics previously recommended for this illness,[1,2] were comparatively low. One recent review of 44 cases of *Serratia* bacteremia from another Ohio hospital reported all organisms susceptible to gentamicin.[12] Interestingly, a study from Spain[14] reported 38% and 47% susceptibility to gentamicin and tobramycin, respectively, and a study from Taiwan[13] reported a susceptibility rate as

low as 28% to gentamicin. In the presence of aminoglycoside resistance, amikacin is often the recommended drug,[2] since susceptibility rates to amikacin are commonly reported to be higher. This study reports a high susceptibility to carbenicillin, whereas others report resistance.[2] These data suggest that the ideal way to initiate therapy for this illness may be to treat with a third-generation cephalosporin and an aminoglycoside. This regimen may be modified depending on the antibiotic sensitivities identified through cultures later. Oral trimethoprim/sulfamethoxazole by these data may be excellent therapy for uncomplicated *Serratia* cystitis.

While a smaller proportion of patients who were treated appropriately (according to study criteria) died than the proportion who were treated inappropriately, the numbers are too small to be statistically significant. The mortality rate for this opportunistic type of bacteremia (25%) was higher than the mortality rate for the controls, although not significantly so. Other studies report comparatively high mortality rates for *Serratia* bacteremia of 26.5%,[6] 38%,[14] 39%,[13] and 52%,[12] although the definition of mortality in these studies was apparently less rigorous, since they did not use other criteria, nor did they set a limit of time after the bacteremia during which death could be attributed to the infection. A 1968 study[15] reported a mortality rate of 36%.

One potential problem with this study is the inclusion of the mid-1980s data from Florida with the Dayton data. This was done to give a wider-scale overview of *Serratia* bacteremia in the community hospital as well as to obtain as large a sample as possible. However, with the growing prevalence of acquired immune deficiency syndrome (AIDS), it is possible that there are some temporal changes that would affect the comparability of the sites. We are not aware of any changes in microbiological techniques, or evidence from the literature of changes in prevalence or severity of *Serratia* infections since the early to mid-1980s. Although AIDS may have changed the spectrum of infections seen by family physicians since then, none of the cases in this study (*Serratia* or control group) were known to have AIDS or be positive for the human immunodeficiency virus. Another problem noted during the course of this study on *Serratia* bacteremia was the great diversity of definitions of associated factors as well as the numerous points of emphasis needed for a study of this type. We felt, however, that it was necessary to include these in designing the most descriptive study possible.

This study shows *Serratia* bacteremia to be an important cause of morbidity and mortality in the community hospital. It will be interesting to see if the incidence of nosocomial bacteremia decreases in an age of managed care, when, ideally, hospitalizations will be fewer and less lengthy. While the data in this study do not deal directly with the mode of transmission of this organism, hand-to-hand transmission by hospital personnel is felt to be the predominant mode of its spread. This would once again underscore the importance of hospital workers washing their hands between patients, especially in intensive care settings where there is a greater preponderance of debilitated patients as well as intravascular catheters.

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