Infectious Diseases Diagnosis & Treatment
Al Maskari Z, et al. Infect Dis Diag Treat 6: 191.
www.doi.org/ 10.29011/2577- 1515.100191
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Research Article

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Rapid Control of *Serratia marcescens* Outbreak in Neonatal Intensive Care Unit, Oman

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Citation: Al Maskari Z, Al Hinnai M, Al Ghabshi L, Panchatcharam SM, Al Rashdi A, Al Jardani A et al. (2022) Rapid Control of *Serratia marcescens* Outbreak in Neonatal Intensive Care Unit, Oman. Infect Dis Diag Treat 6: 191. DOI: 10.29011/2577-1515.100191

Received Date: 11 April 2022; **Accepted Date:** 18 April 2022; **Published Date:** 22 April 2022

Abstract

Introduction: *Serratia marcescens* is an important opportunistic pathogen combining a propensity for healthcare-associated infection and antimicrobial resistance. Outbreaks are frequently reported in neonatal intensive care units (NICUs). **Objectives:** The aim of this study is to describe the epidemiological characteristics of neonates in an outbreak of *S. marcescens* in NICU in a tertiary care hospital, discuss the control measures implemented, addressing challenges and the role that molecular typing could play in routine investigations of outbreaks. **Method:** from September to October 2018, the NICU of our hospital experienced an outbreak of *Serratia marcescens*. A weekly screening for Serratia was initiated for all neonates at risk, environmental microbiological sampling was conducted, and five clinical isolates were typed using PFGE. An unmatched case-control study was carried out to investigate risk factors for infection/colonization. **Results:** A total of 96 neonates were screened for *Serratia marcescens* between 5th September 2018 and 31st December 2018. 153 screening rectal samples, 11 wound and 39 ET secretions were obtained. A total of 8 neonates were positive apart from the index case. five cases had bacteremia, three cases remained colonized and one had conjunctivitis. Unfortunately, 3 of the bacteremia cases died. All neonates were premature and the time from admission to acquisition of Serratia ranged from 5 to 70 days with mean of 16.9 days and a median of 9 days. Environmental samples were all negative. PFGE showed two clusters were involved. In univariate analysis, the mode of delivery (P value 0.003) and ventilation mode (P value 0.008) were significant risk factor. Multivariate analysis could not be done due to small number of the cases. **Conclusion:** *Serratia marcescens* can spread rapidly among neonates in NICU. Although outbreaks can be controlled through enhancing infection control measures and a multi-disciplinary approach, mortality is a significant risk to neonates' safety.

Introduction

Serratia marcescens is an important opportunistic pathogen combining a propensity for healthcare-associated infection and antimicrobial resistance. Outbreaks are frequently reported in Neonatal Intensive Care Units (NICUs) [1,2]. *S. marcescens* gives rise to a wide range of clinical manifestations in newborns: from asymptomatic colonization to keratitis, conjunctivitis, urinary tract infections, pneumonia, surgical wound infections, sepsis, bloodstream infection and meningitis. The most frequent site of infection, however, is the bloodstream, followed by the respiratory apparatus and the gastrointestinal tract. [3,4] The reservoirs most frequently associated with outbreaks of nosocomial infection, particularly in NICUs, are washbasins, tap water, air-conditioning systems, bronchoscopes, laryngoscopes, nebulizers, ventilation equipment, milk drawers, mother's milk, injectable solutions,

liquid soap dispensers, baby shampoo, etc. [5].

The aim of this study is to describe the epidemiological characteristics of neonates in an outbreak of *S. marcescens* in NICU in a tertiary care hospital and discuss the control measures implemented, addressing challenges and the role that molecular typing could play in routine investigations of outbreaks.

Methods

Settings

The study was conducted in 827 beds, a tertiary care government hospital in Muscat. The NICU is 35 beds capacity. The unit has five rooms, of which one is allocated for critically ill patients (High Dependency HD), which accommodate eight beds. The second room is allocated for intermediate dependency (ID) care and has six beds. In case of a surge of critical cases, the beds in ID room are converted to HD beds with a maximum expansion of 14 beds in total which may lead to mixing HD and ID care cases. The staff to patient ratio in the HD room is 1:1; however, it may increase to 1:2 during peaks of HD cases admission in those two rooms. The other two rooms with 21 beds are allocated for low dependency care neonates and mainly were cared for by other staff during the shift with one in charge nurse who oversees the whole unit's work. The unit also has a cohort room with one door and has a small side room that accommodates one case. The rest of the room accommodates three cases for contact isolation purposes with separate staffing from the rest (Only stable cases are cohorted). The unit serves the country for neonatal surgeries, including cardiac surgeries. In addition, complex neonatal cases are referred for diagnosis and further management. The annual total admission range between 916 and 1123 with an average of 1040. The NICU has 128 HCWs, including neonatologists, nurses and medical orderlies. The unit consistently receives few medical officers and nurses for training purposes. All NICU HCWs and those who newly join the unit get basic training in infection prevention and control principles.

Outbreak investigation

In September 2018, the NICU of our hospital experienced an outbreak of *Serratia marcescens*. The index case was admitted in September 2017 who had an infection with *Serratia marcescens* and was isolated under contact precautions in a single room in the cohort room. The same case had another *Serratia marcescens* bacteremia on 25th August 2018. On 1st September 2018, another newborn admitted to HD room developed *Serratia marcescens* bacteremia and had no contact with the index case. Urgent retrospective surveillance by reviewing all positive microbiological cultures for the unit was conducted to ensure that no cases were missed from December 2017 to August 2018 and the finding of which there were no cases of *Serratia marcescens*. Therefore, IP&C declared the outbreak and started investigating and controlling the outbreak. A case definition was developed, and an active weekly screening for *Serratia marcescens* was initiated. The epidemic curve was plotted as shown in figure 1. Extensive environmental microbiological sampling was conducted, and five blood isolates were typed using Pulse Field Gel Electrophoresis (PFGE). ORION checklist was completed as in Table 1 [6].

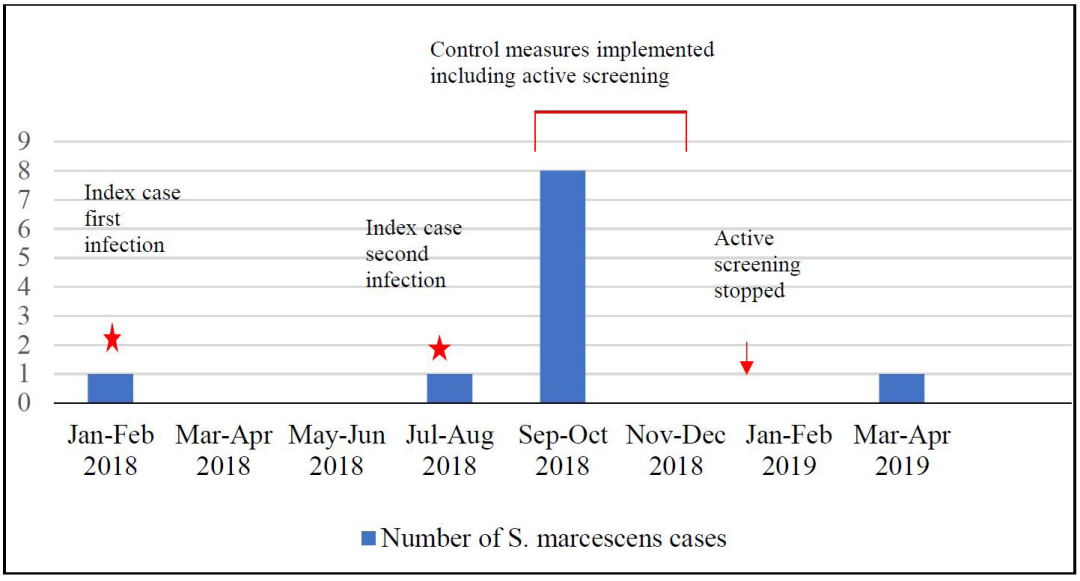

Figure 1: Number of positive *Serratia* Cases Jan 2018-Apr 2019 in NICU (Epidemic Curve)

Article Section	Item Number	Descriptor	The article checks
Title & Abstract	1	Description of paper as outbreak report or intervention study.	Outbreak, mentioned in the title
		Design of intervention study (e.g. ITS with or without control group, cross-over study).	Not applicable
		Brief description of intervention and main outcomes.	Done
Introduction	2	Scientific and/or local clinical background and rationale.	Done in the introduction section
Background		Description of organism as epidemic, endemic or epidemic becoming endemic.	In the discussion. It was addressed in this section that a broader study to know the epidemiology of this organism in our settings
Type of paper	3	Description of paper as intervention study or an outbreak report. If an outbreak report, report the number of outbreaks.	The paper focus in one outbreak that could be controlled rapidly and focus on the importance of molecular typing
Dates	4	Start and finish dates of the study or report.	The outbreak between September 2018 to October 2018, the outbreak declared to be controlled on end of December 2018. This was described in the method section
Objectives	5	Objectives for outbreak reports. Hypotheses for intervention studies.	Mentioned in the objective section of the introduction
Methods	6	Study design. Use of EPOC classification recommended (CBA, or ITS).	Case-control for the risk factors
Design		Whether study was retrospective, prospective or am bidirectional.	Prospective during the outbreak
		Whether decision to report or intervene was prompted by any outcome data.	Yes, death among neonates
		Whether study was formally implemented with predefined protocol and endpoints.	Not applicable

Participants	7	Number of patients admitted during the study or outbreak.	Mentioned in the results section
		Summaries of distributions of age and lengths of stays.	Done in the table and results
		If possible, proportion admitted from other wards, hospitals, nursing homes or from abroad.	Not applicable to this outbreak
		Where relevant, potential risk factors for acquiring the organism.	Case-control study done specific for this outbreak
		Eligibility criteria for study.	Mentioned in the method
		Case definitions for outbreak report.	In the method section
Setting	8	Description of the unit, ward or hospital and, if a hospital, the units included.	In the background part of the method
		Number of beds, the presence and staffing levels of an infection control team.	Mentioned in the setting section of the method
Interventions	9	Definition of phases by major change in specific infection control practice (with start and stop dates). A summary table is strongly recommended with precise details of interventions, how and when administered in each phase.	This was not done in this outbreak as the duration was short and all measures were implemented simultaneously.
Culturing and typing	10	Details of culture media, use of selective antibiotics and local and/or reference typing. Where relevant, details of environmental sampling.	Mentioned in the microbiology section of the method including the molecular typing
Infection-related outcomes	11	Clearly defined primary and secondary outcomes (e.g. incidence of infection, colonization, bacteremia) at regular time intervals (e.g. daily, weekly, monthly) rather than as totals for each phase, with at least three data points per phase and, for many two phase studies, or more monthly data points per phase.	The screening was implemented weekly as described in the method section.
		Denominators (e.g., numbers of admissions or discharges, patient bed days). If possible, prevalence of organism and incidence of colonization on admission at same time intervals.	Not applicable to this outbreak
		Criteria for infection, colonization on admission and directly attributable mortality. All-cause mortality.	Mentioned in the method section
		For short studies or outbreak reports, use of charts with duration patient stays and dates organism detected may be useful (see text).	Included in the table 1.
Economic outcomes	12	If a formal economic study was done, definition of outcomes to be reported, description of resources used in interventions, with costs broken down to basic units, stating important assumptions.	Not applicable to this study

Potential threats to internal validity	13	Which potential confounders were considered, recorded or adjusted for (e.g. changes in length of stay, case mix, bed occupancy, staffing levels, hand-hygiene compliance, antibiotic use, strain type, processing of isolates, seasonality)?	Not applicable
		Description of measures to avoid bias including blinding and standardization of outcome assessment and provision of care.	Not applicable to this outbreak
Sample size	14	Details of power calculations, where appropriate.	Not applicable. Case and controls were 1:4. All cases involved in the outbreak were included
Statistical methods	15	Description of statistical methods to compare groups or phases.	Case - Control was conducted to study risk factors for infection among cases mentioned in the method section
		Methods for any subgroup or adjusted analyses, distinguishing between planned and unplanned (exploratory) analysis.	Not done in this paper
		Unless outcomes are independent, statistical approaches able to account for dependencies in the outcome data should be used, adjusting, where necessary, for potential confounders.	Not applicable to this report
		For outbreak reports statistical analysis may be inappropriate.	true
Results Recruitment	16	For relevant designs, such as cross-over studies, or where there are exclusions of groups of patients, the dates defining the periods of recruitment and follow-up, with a flow diagram describing participant flow in each phase.	Not applicable
Outcomes and estimation	17	For the main outcomes, the estimated effect size and its precision (usually using confidence intervals). A graphical summary of the outcome data is often appropriate for dependent data (such as most time series).	Not applicable
Ancillary analyses	18	Any subgroup analysis should be reported and it should be stated whether or not it was planned (i.e. specified in the protocol) and adjusted for possible confounders.	Not applicable to this paper
Harms	19	Pre-specified categories of adverse events and occurrences of these in each intervention group. This might include drug side effects, crude or disease-specific mortality in antibiotic policy studies or opportunity costs in isolation studies.	Not conducted in this study

Discussion	20	For intervention studies an assessment of evidence for/ against hypotheses, accounting for potential threats to validity of inference including regression to mean effects and reporting bias.	Not applicable
		For outbreak reports, consider clinical significance of observations and hypotheses generated to explain them.	This was a small-scale outbreak. hypothesis was not elaborated however in environmental sampling that was conducted in the first 3 weeks of the outbreak we initially collected from surrounding environment then followed by equipment and breast-feeding room based on possible sources
Generalizability	21	External validity of the findings of the intervention study, i.e., to what degree can results be expected to generalize to different target populations or settings. Feasibility of maintaining an intervention long term.	Mentioned in the discussion section
Overall evidence	22	General interpretation of results in context of current evidence.	In the discussion

Table 1: The ORION checklist for the *Serratia marcescens* outbreak report [6].

Microbiological

Screening samples from neonates were collected include rectal swabs, in addition to endotracheal (ET) secretion for ventilated babies, wound if any wound present or eye swab if there is an eye discharge. Nurses collected samples as per infection control instruction during the outbreak and the microbiology laboratory procedures. Samples were inoculated onto *MacConkey* agar, then incubated at 37°C for 24 hours. If no colonies grew after 24 hours, plates were incubated for 48 hours. Eighty-six Environmental samples were collected: from sinks, soap dispensers, wall mounted hand rub dispensers, medications fridge, laryngoscopes, baby incubators, working tables, ultrasound machine, echocardiography machine, crash trollies of both rooms, the medication trolley, the milk room's bottle cleaning area, breast pump membrane, olive oil bottle (shared by mothers in milk room), flow sensors, using Amies swab which was pre-moisten using sterile saline. Similac human milk fortifier (powder), liquid samples include water from ventilator humidifiers, 4% Chlorhexidine gluconate soap, Medium Chain Triglycerides oil were collected in a sterile container. All liquid samples were centrifuged at 3,500 rpm for 10 minutes. The precipitate was inoculated in brain-heart infusion broth for 24 hours then sub-cultured into *MacConkey* agar. *S. marcescens* strains identified and susceptibility tested by BD Phoenix™'s automated identification and susceptibility testing system.

Molecular Analysis

PFGE was performed as per previously described methods with in-house optimization for *S. marcescens* [7,8]. Briefly, fresh over-night growth (18-24 h) on Trypticase Soy Agar (TSA) with 5% defibrinated sheep blood (TSASB) plates were harvested and pellet was suspended in cell suspension buffer (0.8-1 OD concentration at 610 nm photo spectrometer wavelength). Plugs were prepared using 1% SeaKem Gold agarose (Lonza BioSciences). Cell lysis was performed in Cell Lysis Buffer/Proteinase K solution. DNA restriction was done with XbaI restriction enzyme (Cat No. ER0682, Thermo Fisher Scientific). Electrophoresis was performed with a CHEF DRIII system (BioRad Laboratories Inc., Hercules, CA) using the following run parameters: a switch time of 2.2–63.8 s and an optimized runtime of 17.6 h. Salmonella Braenderup strain H9812 was used as the molecular weight marker. Gel images were taken with the Gel/ChemiDoc system (Bio-Rad Laboratories). Analysis & comparison of PFGE fingerprints was done using the BioNumerics Software (5.1 version, Applied Maths).

Case Control Study

To identify the risk factors for acquiring *Serratia marcescens* infection or colonization in this outbreak, we conducted an unmatched case-control study by including neonates admitted between September and December 2018 in the HD room and screened for *Serratia marcescens*. We only included 43 controls as we selected the controls who were admitted in the same two rooms of the unit in which the most critically ill neonates were admitted, and the outbreak occurred. The ratio of cases to control was 1:4.

A case defined as a neonate admitted to NICU HD area between September and December 2018 and tested positive for *Serratia marcescens* either from a screening or clinical sample. The case was considered hospital-acquired if the positive sample was taken after 48 hours of admission to the unit. In contrast, the control was defined as a neonate admitted to NICU HD area between September and December 2018 and tested negative for *Serratia marcescens* either by screening or clinical sample. Colonization is defined as a positive culture for *Serratia marcescens* in the absence of symptoms or signs of infection, and the neonate was not treated with any antibiotics or diagnosed to have an infection by a neonatologist. Infection was defined as a positive culture for *Serratia marcescens*, and signs and or symptoms of infection were present, and the neonate was treated with antibiotics.

Statistical Analysis

Collected data were analyzed using IBM SPSS Statistics 25.0 (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.). For the descriptive purposes, categorized variables were presented with number and percentages, continuous variables presented with Mean with standard deviation or Median with Range. Categorical variables were compared using Chi-square test and continuous variables were compared using Mann-Whitney non-parametric test. The p-value of <0.05 was considered as statistical significance.

Ethical consideration

The study was approved by the hospital ethics and research committee (SRC#16/2020). Data were pulled from the hospital electronic system (AL Shifa 3+).

Results

During the outbreak, the total cases admitted to the unit were 74 in September 2018, 89 in October 2018, 82 in November 2018 and 91 in December 2018. Approximately one-third of these were initially admitted to HD. Ninety-six neonates were screened for *Serratia marcescens* between 5th September 2018 and 31st December 2018. One hundred fifty-three rectal samples, 11 wound and 39 ET secretions were obtained from these neonates. A total of 8 neonates were positive apart from the index case. Three of the cases had bacteremia with an initial negative screening result, and only three cases remained colonized and had no infections. Unfortunately, 3 of the bacteremia cases died. All neonates were premature, and the time from admission to the acquisition of Serratia ranged from 5 to 70 days, with a mean of 16.9 days and a median of 9 days. Table 2 summarize the data of the positive cases.

Case No.	Case No. in PFGE Figure 2	Age (Days)	Sex	Diagnosis	Date of positive *S. marcescens*	Sample type positive	Infection versus Colonization	Type of infection	No. of Screening samples done before positive culture	Outcome
1•	1	270 • first infection was at 70 days of admission	F	Prematurity (24 W), Cerebral Palsy, Chronic Lung Disease	25.08.2018	Blood	infection	VAP, Bacteremia	None	Died
2*	2	5	F	Prematurity (29 W), RDS	30.08.2018	Blood	infection	Primary Bacteremia	None	Died
3*	NA	8	F	Pre-term (29 W), RDS	02.09.2018	Rectal Swab	Colonization		First screen positive	Discharged
4	NA	7	F	Pre-term (28 W), RDS	10.09.2018	Eye swab	infection	conjunctivitis	1 (negative)	Discharged
5*	NA	18	F	Pre-term (29 W), RDS	13.09.2018	Rectal Swab	Colonization		1 (negative)	Discharged
6*	NA	18	M	Pre-term (29 W), RDS	13.09.2018	Rectal Swab	Colonization		1 (negative)	Discharged

7	3	10	F	Pre-term (34W), IUGR, hypoglycemia	28.09.2018	Blood	Infection	Peripheral line infection, Bacteremia	1 (negative)	Died
8	4	7	M	Pre-term (28 W)	18.10.2018	Blood	Infection	Bacteremia	1 (negative)	Discharged
9	5	9	F	Pre-term (31 W), IUGR	31.10.2018	Blood	Infection	Bacteremia	1 (negative)	Discharged
•Index Case, *Quintuplets, W: Weeks of Gestation, RDS: Respiratory Distress Syndrome, IUGR: Intrauterine Growth Retardation, NA: Not Applicable										

Table 2: Clinical characteristics of neonates who had positive *Serratia marcescens* cultures during outbreak September-December 2018.

In univariate analysis, the mode of delivery was a significant risk factor in that 88.8% (n=8) of cases were delivered by Lower Segment Cesarean Section (LSCS), both emergency and elective, with a P-value of 0.003. In addition, ventilation mode was statistically significant with P value of 0.008 where 88.9% (n=8) of cases were on CPAP while in the control group 55.8% (n=24) were on CPAP, 44% (n=18) were intubated and 2.3% (n=1) were on room air. The rest of the risk factors were insignificant, as detailed in Table 3. The multivariate analysis could not be done due to the small number of cases and the controls.

Variables	Cases		Controls		p-Value
	n	%	n	%	
Gestational weeks					
< 33 weeks	8	88.9	29	67.4	0.257
≥ 33 weeks	1	11.1	14	32.6	
Mode of delivery					
Elective Caesarean Section	4	44.4	1	2.3	
Emergency Caesarean Section	4	44.4	27	628	0.003
Spontaneous Vaginal Delivery	1	11.1	15	34.9	
Baby weight					
≤ 1000 grams	2	22.2	20	46.5	0.272
> 1000 grams	7	77.8	23	53.5	
≤ 1500 grams	9	100.0	29	67.4	0.092
> 1500 grams	-	-	14	32.6	
Ventilation mode					
Intubation	-	-	18	41.9	
Nasal cannula	1	11.1	-	-	0.008
Nasal Continuous Positive Airway Pressure (CPAP)	8	88.9	24	55.8	
Room air	-	-	1	2.3	

Humidification of incubator Yes No	7 2	77.8 22.2	21 22	48.8 51.2	0.152
Surgeries Yes No	1 8	11.1 88.9	6 37	14.0 86.0	1.000
Total Parenteral Nutrition Yes No	9 -	100.0 -	36 7	83.7 16.3	0.331
Use of ultrasound machine Yes No	9 -	100.0 -	39 4	90.7 9.3	1.000
Use of echocardiography machine Yes No	6 3	66.7 33.3	24 19	55.8 44.2	0.717
Phototherapy Yes No	9 -	100.0 -	33 10	76.7 23.3	0.178
Length of stay in NICU (Median (Range))	22 (80)		13 (74)		0.163
Length of High Dependency stay (Median (Range))	13 (74)		22 (81)		0.156

Table 3: Association between risk factors with cases and controls.

The environmental samples were all negative. Molecular typing was performed only in 5 isolates from the blood culture as the laboratory saved these strains. As shown in figure 2, Case 2, case 3 and case 4 isolate are part of one cluster. The index case (case 1) and case 5, are not part of the same cluster.

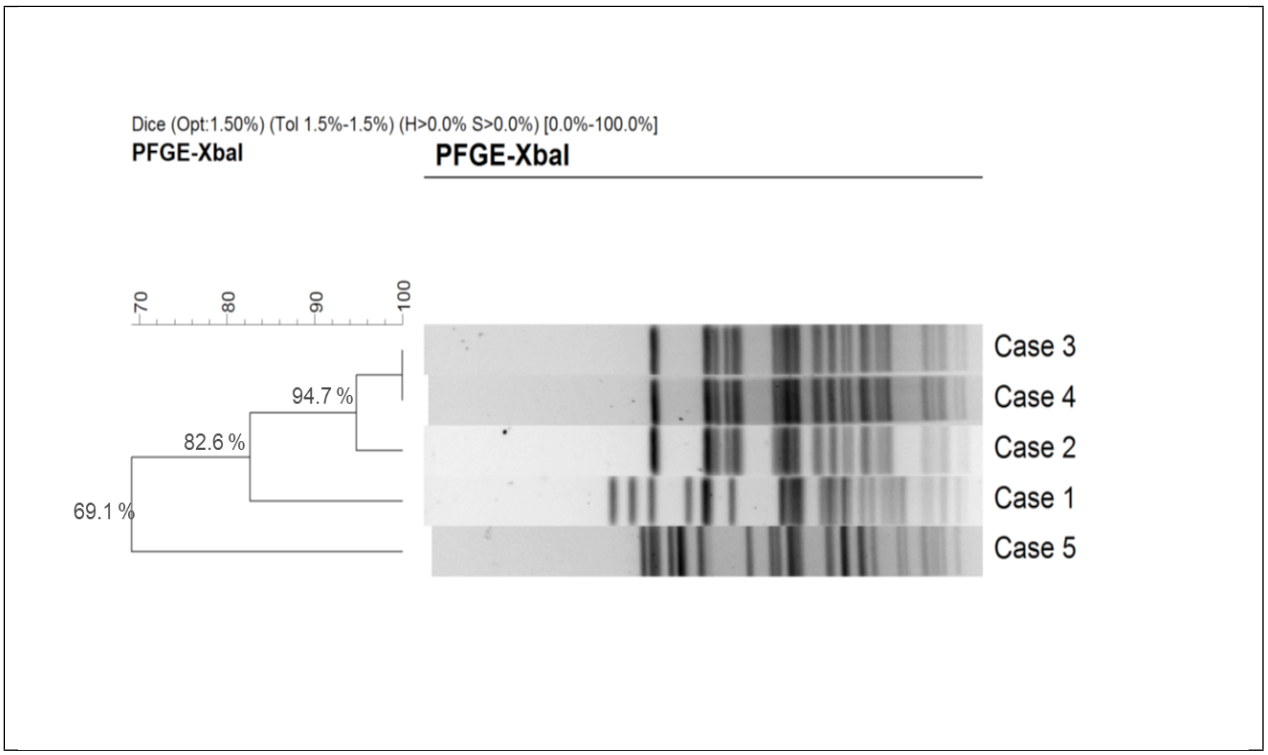

Figure 2: XbaI PFGE dendrogram of *Serratia marcescens* isolated from a tertiary care hospital in Oman. Case 3&4 are identical and form a cluster. Case 2 is highly close to case 3&4 and appears to be ancestor clone. Case 1 and case 5 are not part of the cluster.

During the outbreak, we observed overcrowding due to a surge of premature neonates admitted to HD. In addition, the cleaners were using one towel to clean the surrounding environment of the cots/incubators for the whole room. The echocardiography and ultrasound machines were not cleaned or disinfected between neonates, and no responsible HCW to follow their cleanliness or disinfection. The hand hygiene of outsiders of the unit was suboptimal and not monitored.

The infection control measures

All neonates with positive *Serratia marcescens* were cohorted. Cohorting staff for infected neonates was not practiced due to staff limitations. The unit was partially closed in the first three weeks of the outbreak, where the unit only accepts critically ill neonates born in the hospital. Active screening surveillance continued till the end of December 2018. Enhanced education of the HCWs about the organism and the infection control measures was conducted and continued to monitor hand hygiene compliance rate. We enhanced environmental, non-critical and semi-critical medical devices cleaning and disinfection, which was monitored directly by the infection control practitioner daily. A log was hung on the ultrasound and echocardiography machine with the dates, the user and confirmation of the cleaning disinfection required between each neonate use. The cleaners used one towel for each bed surroundings. Terminal cleaning and hydrogen peroxide vapour were implemented to HD and ID when all neonates became stable and discharged. Other departments that contribute to NICU care, such as radiology, child health, environmental service, pediatric surgery, and pediatric cardiac surgery, were informed about the outbreak and the importance of enhancing hand hygiene measures. The parents were educated about the importance of their hand hygiene compliance before attending to their baby.

Discussion

Serratia marcescens is known to cause frequent outbreaks in NICU [1,3,6]. Although this is a small outbreak, all the neonates affected in this outbreak were premature, and the death rate among positive cases was high. A point to mention is that four of the affected neonates were siblings (quintuplets) and were in the HD room, which might have contributed to the rapid propagation of the

outbreak. The role of the mother in cross-transmission of *Serratia marcescens* has been postulated by other researchers previously [2].

The index case had a previous infection, *Serratia marcescens* and remained negative from any clinical culture for an extended period. She had another episode of infection, which Support continuous isolation of such cases as long as they are inpatients. Unfortunately, we could not retrieve the previous strain to compare it with the latest strain.

Many studies highlighted the risk factors for infection or colonization [2,5]. In this outbreak, due to the small number of cases and controls, we could not do a multivariate analysis to highlight the independent risk factors for acquiring this organism. In our setting, this organism is endemic warrants a broader study to pinpoint the risk factors for infection and or colonization specific to our hospital. The unit space limitation and the points discussed earlier triggered the outbreak.

As in most *Serratia marcescens* outbreaks reported, the source of this outbreak was not identified [4,5,9,13], but the molecular epidemiology highlighted the clustering of these strains, which mean there was cross-transmission in the units. The source of this transmission is likely to be the HCWs' hands. We did not perform HCWs' hand microbiological sampling considering that it is not the source; rather, it is a transmission vehicle. Several studies previously reported negative HCWs screening for *Serratia marcescens* [1,2,12,13].

The molecular typing of the strains involved in the outbreak is vital to identify the clonality of the strains and aid infection control practitioners in focusing on the measures. Many studies addressed the role of molecular epidemiology in controlling the outbreak and understanding the epidemiology of this organism in their settings [4,10,13,14].

We believe that we controlled this outbreak rapidly through enhancing infection control measures implementations; however, the sustainability of preventing such outbreaks in the future is a challenge. Risk-based *Serratia marcescens* active screening surveillance among premature infants admitted to NICU could be introduced; however, it might be difficult in our hospital, as our unit screen neonates received from other hospitals for other Multidrug Drug-Resistant organisms such as Methicillin-Resistant Staphylococcus aureus and Extended Spectrum Beta-Lactamase producing Enterobacterales. In addition, the cost-effectiveness of such an approach should be studied. Furthermore, HCWs must practice enhanced infection control measures, especially at peak admissions, which is known to provoke outbreaks of infectious micro-organisms.

There are limitations to this outbreak investigation. First, we could not do molecular typing of all the strains involved in the outbreak. Second, our unit is collecting once a week and only a rectal swab for screening for is stable neonates, which might have limited our detection of *Serratia marcescens* colonization. Some experts recommend that both respiratory and Gastrointestinal samples be collected for screening to maximize the identification of colonized infants [2,5]. Third, we have not used selective media for *Serratia marcescens*.

Conclusion

Serratia marcescens can spread rapidly among neonates in NICU. Although outbreaks can be controlled through enhancing infection control measures and a multi-disciplinary approach, mortality is a significant risk to neonates' safety. NICUs and infection preventionists at any hospital should maintain zero outbreaks of this organism.

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