

Healthcare-Associated Methicillin-Resistant *Staphylococcus aureus*

Clinical characteristics and antibiotic resistance profile with emphasis on
macrolide-lincosamide-streptogramin B resistance

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البكتيريا العنقودية الذهبية المقاومة للميثيسيلين المرتبطة بالرعاية الصحية
الخصائص السريرية و مقاومة المضادات الحيوية مع التركيز على مقاومة الماكروليد واللينكوساميد-ستربتوغرامين B

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ABSTRACT: Objectives: Healthcare-associated methicillin-resistant *Staphylococcus aureus* (MRSA) is a common pathogen worldwide and its multidrug resistance is a major concern. This study aimed to determine the clinical characteristics and antibiotic susceptibility profile of healthcare-associated MRSA with emphasis on resistance to macrolide-lincosamide-streptogramin B (MLS_B) phenotypes and vancomycin. **Methods:** This cross-sectional study was carried out between February 2014 and February 2015 across four tertiary care hospitals in Mangalore, South India. Healthcare-associated infections among 291 inpatients at these hospitals were identified according to the Centers for Disease Control and Prevention guidelines. Clinical specimens were collected based on infection type. *S. aureus* and MRSA isolates were identified and antibiotic susceptibility tests performed using the Kirby-Bauer disk diffusion method. The minimum inhibitory concentration of vancomycin was determined using the Agar dilution method and inducible clindamycin resistance was detected with a double-disk diffusion test (D-test). **Results:** Out of 291 healthcare-associated *S. aureus* cases, 88 were MRSA (30.2%). Of these, 54.6% were skin and soft tissue infections. All of the isolates were susceptible to teicoplanin and linezolid. Four MRSA isolates exhibited intermediate resistance to vancomycin (4.6%). Of the MRSA strains, 10 (11.4%) were constitutive MLS_B phenotypes, 31 (35.2%) were inducible MLS_B phenotypes and 14 (15.9%) were macrolide-streptogramin B phenotypes. **Conclusion:** Healthcare-associated MRSA multidrug resistance was alarmingly high. In routine antibiotic susceptibility testing, a D-test should always be performed if an isolate is resistant to erythromycin but susceptible to clindamycin. Determination of the minimum inhibitory concentration of vancomycin is necessary when treating patients with MRSA infections.

Keywords: Healthcare Associated Infections; Antibiotic Resistance; Methicillin-Resistant *Staphylococcus aureus*; Phenotypes; Clindamycin; Vancomycin.

المخلص: أهداف: تعتبر مقاومة المكورات العنقودية للميثيسيلين المرتبطة بالرعاية الصحية ميرسا (MRSA) من مسببات الأمراض الأكثر شيوعاً في جميع أنحاء العالم ومقاومتها للأدوية المتعددة مصدر قلق كبير. هدفت هذه الدراسة إلى تحديد الخصائص السريرية وخصائص الحساسية للمضادات الحيوية لهذه الجرثومة المتعلقة بالرعاية الصحية مع التركيز على مقاومتها لـ مكاروليد لينكوساميد ستربتوغرامين B و الفانكوميسين. منهجية: أجريت هذه الدراسة المستعرضة في الفترة ما بين فبراير 2014 وفبراير 2015 في أربع مستشفيات للرعاية الثالثية في مانجالور بجنوب الهند. وقد تم تحديد العدوى المتعلقة بالرعاية الصحية من بين 291 من المرضى المنومين في هذه المستشفيات وفقاً لتعليمات مراكز السيطرة على الأمراض والوقاية منها. تم جمع العينات السريرية بناءً على نوع الإصابة. وقد تم تحديد بكتيريا المكورة العنقودية والميرسا وأجريت اختبارات الحساسية باستخدام طريقة كيربي باور بأقراص المضادات الحيوية. تم تحديد الحد الأدنى للتركيز المثبط للفانكوميسين باستخدام طريقة تخفيف الأجار ومقاومة الكلينداميسين وتم الكشف عنها باختبار الانتشار المزدوج لأقراص D- . نتائج: من 291 حالة متعلقة بالرعاية الصحية، 88 حالة كانت بسبب ميرسا (30.2%). منها 54.6% حالة التهابات جلدية وأنسجة رخوة. وكانت جميع العينات المعزولة حساسة للتيكوبلانين وبنزوليد. أظهرت أربعة عينات جرثومية معزولة مقاومة متوسطة للفانكوميسين (4.6%). 10 (11.4%) من عينات ميرسا كانت من نوع MLS_B الأساسية، و 31 (35.2%) من نوع MLS_B المحرض و 14 (15.9%) كانوا من النوع المقاوم لـ مكاروليد ستربتوغرامين B. خاتمة: إن نسبة مقاومة المكورات العنقودية للميثيسيلين المرتبطة بالرعاية الصحية عالية ومقلقة: ينبغي أن يؤدي فحص D دائماً في اختبارات الحساسية للمضادات الحيوية الروتينية إذا كانت العينة المعزولة مقاومة للإريثروميسين لكن حساسة لكلينداميسين. تحديد الحد الأدنى لتركيز مثبط للفانكوميسين ضروري عند علاج المرضى الذين يعانون من التهابات ميرسا.

كلمات مفتاحية: العدوى المرتبطة بالرعاية الصحية؛ مقاومة المضادات الحيوية؛ المكورات العنقودية الذهبية المقاومة للميثيسيلين؛ الظواهر؛ كلينداميسين؛ فانكوميسين.

ADVANCES IN KNOWLEDGE

- A high rate of inducible macrolide-lincosamide-streptogramin B (MLS_B) phenotypes were found among healthcare-associated methicillin-resistant *Staphylococcus aureus* (MRSA) isolates identified from clinical specimens in the current study.
- Four cases of healthcare-associated MRSA with intermediate resistance to vancomycin were detected. This finding challenges the efficacy of vancomycin in cases of serious multidrug-resistant healthcare-associated MRSA infections.

APPLICATION TO PATIENT CARE

- The results of this study indicate the necessity of performing double-disk diffusion tests to identify inducible MLS_B resistance to prevent the therapeutic failure of clindamycin in healthcare-associated MRSA cases.
- Additionally, these findings suggest that the minimum inhibitory concentration of vancomycin should be determined in order to guide therapy.

METHICILLIN-RESISTANT *STAPHYLOCOCCUS aureus* (MRSA) was first identified in the 1960s and continues to be a significant pathogen worldwide, causing a variety of infections from minor skin and soft tissue infections to severe osteomyelitis, bacteraemia and sepsis.¹ Healthcare-associated MRSA spreads through direct or indirect contact and normally exhibits multidrug resistance.¹ The distribution of healthcare-associated MRSA varies geographically; rates in the Western Pacific region, Latin America, the USA and Europe are 46.0%, 34.9%, 34.2% and 26.3%, respectively.² In contrast, northern European countries such as Denmark, the Netherlands, Iceland and Sweden have reported rates of <1.0%.³ In Asia, the prevalence varies from 22.6–86.5%, with the highest rate reported in Sri Lanka and the lowest in India.⁴ Nevertheless, the rate of healthcare-associated MRSA in India has steadily increased over the past few years, from <20.0% in 2002 to 39.6% in 2012.^{5–8}

The rise of multidrug-resistant healthcare-associated MRSA cases has reduced the number of available therapeutic options for these infections. Potential antibiotics include daptomycin, linezolid, quinupristin/dalfopristin, trimethoprim/sulfamethoxazole and vancomycin.⁹ Glycopeptides, in particular vancomycin, are the treatment of choice for serious infections.⁹ The macrolide-lincosamide-streptogramin B (MLS_B) group of antibiotics can be used to treat less severe skin and soft tissue infections.⁹ The lincosamide antibiotic clindamycin is often preferred because of its low cost and pharmacokinetic properties, including significant tissue penetration, an extended half-life and the ability to inhibit toxin production.^{9,10} Unfortunately, the widespread use of MLS_B antibiotics has resulted in increased resistance which occurs either due to an efflux mechanism encoded by the *methionine sulfoxide reductase A* gene or a ribosomal target site modification encoded by the *erythromycin ribosomal methylase* gene.¹⁰ Constitutive MLS_B (cMLS_B) resistance can be detected in routine susceptibility testing by its resistance to both erythromycin and clindamycin; in contrast, bacteria with inducible MLS_B (iMLS_B) resistance

appear resistant to erythromycin but susceptible to clindamycin in routine testing, thereby posing a problem in detection.¹⁰ As a result, if clindamycin is used for the treatment of infections caused by these strains, the treatment will fail. It is therefore important to detect this kind of resistance.

The available literature does not reveal precise data on MLS_B-resistant phenotypes and the susceptibility profile to vancomycin among healthcare-associated MRSA-affected populations from South India. Consequently, the present study was conducted to determine the clinical characteristics and antibiotic susceptibility patterns of MRSA isolates from clinical specimens taken from a South Indian cohort, with emphasis on the aforementioned factors.

Methods

This cross-sectional study was conducted from February 2014 to February 2015 among four tertiary care hospitals in Mangalore, South India. Two of the hospitals were governmental hospitals with 600 and 250 beds, respectively, while the other two were private hospitals with 510 and 251 beds, respectively. The governmental hospitals had general surgery and neurosurgical departments, burn units, general intensive care units (ICUs) and urology, nephrology, dermatology, gynaecology and paediatric wards. In addition to the aforementioned departments, the private hospitals also had oncology, haematology, cardiothoracic and nephrosurgery departments as well as general, nephrosurgery, neurosurgery and cardiothoracic ICUs.

The inclusion criteria included inpatients presenting to one of the four hospitals with localised or systemic conditions resulting from the presence of an infectious agent or its toxins which was not present or incubating at the time of admission to the hospital but only became evident 48 hours after admission or longer. In addition, patients with a history of hospitalisation, haemodialysis, surgery or admission to a long-term healthcare facility within the previous

year and those with indwelling catheters, intravenous lines or other percutaneous medical devices at the time of culture collection were included. Outpatients and those with no healthcare-associated MRSA risk factors who were diagnosed with an *S. aureus* infection within 48 hours of hospitalisation were excluded.^{11,12} The sample size was calculated using the following formula:¹³

$$n = \frac{Z_{1-\alpha}^2 pq}{d^2}$$

where $Z_{1-\alpha}$ is 1.96 (95% confidence interval), p is 0.37 (expected proportion), q is 0.63 (1- p) and d is 0.0555 (relative precision of 15% of p , i.e. allowable error). The expected proportion was selected based on a previous study.¹⁴ The total sample size required was therefore 291 patients.

The criteria of the Centers for Disease Control and Prevention were used to identify healthcare-associated infections due to *S. aureus*.¹² A structured *pro forma* was used to collect the demographic and clinical details of the patients. Based on the type and site of infection, clinical specimens such as pus/exudates, blood, *sputum* and indwelling medical devices (i.e. central line tips, peripheral intravenous catheters, endotracheal tubes and urinary catheters) were collected from the patients and processed by the Department of Microbiology at the Kasturba Medical College in Mangalore. Gram staining of the specimens was performed followed by blood agar and MacConkey's agar cultures using standard bacteriological procedures.¹⁵ *S. aureus* bacteria were identified by colony morphology, Gram staining and catalase, slide and tube coagulase and deoxyribonuclease tests.¹⁵ The cefoxitin (30.00 µg) disk diffusion method was used to detect methicillin resistance in *S. aureus* isolates.¹⁶

Antibiotic susceptibility was tested using the Kirby-Bauer disk diffusion method and the results interpreted using the guidelines of the Clinical and Laboratory Standards Institute (CLSI).¹⁶ The following antibiotics were tested: ciprofloxacin (5.00 µg), clindamycin (2.00 µg), trimethoprim/sulfamethoxazole (1.25 µg/23.75 µg), erythromycin (15.00 µg), gentamicin (10.00 µg), linezolid (30.00 µg), penicillin (10 U), rifampicin (5.00 µg) and teicoplanin (30.00 µg). All antibiotics were purchased from HiMedia Laboratories Ltd. (Mumbai, Maharashtra, India). An *S. aureus* strain (ATCC® 25923™, American Type Culture Collection, Manassas, Virginia, USA) was used as the control.

The minimum inhibitory concentration (MIC) of vancomycin was determined by the agar dilution method using CLSI guidelines.¹⁷ Gradient plates of Mueller-Hinton agar were prepared with vancomycin

(0.062–128.000 µg/mL). Three or four MRSA colonies grown on blood agar were picked and inoculated in Mueller-Hinton broth (MHB) and incubated at 35 °C for 4–6 hours. The turbidity of the broth culture was matched with a 0.5 McFarland standard (bacterial count ≈ 1.5 × 10⁸ colony-forming unit [cfu]/mL) and then diluted at a ratio of 1:10 in sterile MHB to ensure a concentration of 1.5 × 10⁷ cfu/mL. From this culture, 2 µL of the suspension was spot-inoculated on each plate and incubated at 35 °C for 24 hours. MRSA strains with MICs of ≤2.00 µg/mL, 4.00–8.00 µg/mL and ≥16.00 µg/mL were considered susceptible, intermediate and resistant to vancomycin, respectively.¹⁶ *S. aureus* (ATCC® 29213™, American Type Culture Collection) and *Enterococcus faecalis* (ATCC® 29212™, American Type Culture Collection) strains were used as vancomycin-susceptible controls. Another *E. faecalis* strain (ATCC® 51299™, American Type Culture Collection) was used as the vancomycin-resistant control.

The MLS_B phenotypes were identified as described previously.^{16,18} MRSA strains resistant to both erythromycin and clindamycin in routine antibiotic susceptibility testing were considered cMLS_B phenotypes. A double-disk diffusion test (D-test) was performed to determine MRSA strains which were resistant to erythromycin but sensitive to clindamycin (iMLS_B phenotypes). Erythromycin (15.00 µg) and clindamycin (2.00 µg) disks were placed on a Mueller-Hinton agar plate containing a lawn culture of the test isolate at a distance of 15 mm edge to edge. The plate was incubated at 35 °C for 16–18 hours. Any flattening of the zone of inhibition (D-shape) around the clindamycin disk adjacent to the erythromycin disk was subsequently observed; strains with a D-shaped zone of inhibition were considered iMLS_B phenotypes. Strains of MRSA which were resistant to erythromycin, susceptible to clindamycin and were also D-test negative (had no D-shaped zone of inhibition) were considered macrolide-streptogramin B (MS_B) phenotypes.

The Statistical Package for the Social Sciences (SPSS), Version 16.0 (IBM Corp., Chicago, Illinois, USA) was used to analyse the data. Rates of MRSA infections were presented as percentages. The Pearson's Chi-squared test was used to analyse results between the two groups of categorical variables. A P value of ≤0.050 was considered statistically significant.

This study was approved by the Institutional Ethics Committee of Kasturba Medical College (#IECKMCLR01-14/14). Informed consent was collected from all patients prior to their participation in the study.

Table 1: Type of healthcare-associated methicillin-resistant *Staphylococcus aureus* and methicillin-sensitive *Staphylococcus aureus* infections (N = 291)

Type of infection	n (%)		P value*
	MRSA (n = 88)	MSSA (n = 203)	
Surgical site	18 (20.5)	77 (37.9)	0.004†
Cellulitis	17 (19.3)	25 (12.3)	0.118
Bed sore	11 (12.5)	16 (7.9)	0.212
Catheter-associated bacteraemia	14 (15.9)	3 (1.5)	<0.001†
Ulcer	8 (9.1)	23 (11.3)	0.569
Burn wound	8 (9.1)	28 (13.8)	0.263
TEN	3 (3.4)	5 (2.5)	0.665
Bacteraemia	6 (6.8)	2 (1.0)	0.005†
<i>Psoas</i> abscess	1 (1.1)	0 (0.0)	0.665
Empyema	1 (1.1)	0 (0.0)	0.665
Pneumonia	0 (0.0)	8 (3.9)	0.134
Osteomyelitis	1 (1.1)	14 (6.9)	0.041
Catheter-associated UTI	0 (0.0)	2 (1.0)	0.350

TEN = toxic epidermal necrolysis; MRSA = methicillin-resistant *Staphylococcus aureus*; MSSA = methicillin-sensitive *Staphylococcus aureus*; UTI = urinary tract infection.

*Determined using the Chi-squared test. †Statistically significant at $P \leq 0.050$.

Results

A total of 291 non-repetitive healthcare-associated-*S. aureus* cases were isolated during the study period; 119 and 12 cases were from the two governmental hospitals and 95 and 65 cases were from the two private hospitals, respectively. The rates of healthcare-associated MRSA in the two government hospitals and two private hospitals were 41.2%, 33.3%, 22.1% and 21.5%, respectively. No statistically significant differences were observed between male and female patients. Patients aged 31–40 and 41–50 years old were most likely to be infected with MRSA. The different types of *S. aureus* infections found are shown in Table 1. Of the *S. aureus* cases, 95 (32.7%) were isolated from surgical site infections, 42 (14.4%) from cellulitis cases, 25 (8.6%) from blood stream infections (including bacteraemia and catheter-associated bacteraemia infections) and 15 (5.2%) from osteomyelitis cases. A total of 88 *S. aureus* cases (30.2%) were methicillin-resistant. Of the MRSA cases, 54.6% were skin and soft tissue infections, comprising cellulitis, bed sore, ulcer, burn wound, toxic epidermal necrolysis and *psoas* abscess infections. MRSA was significantly more frequent in bacteraemia infections while methicillin-

Table 2: Antibiotic resistance patterns of healthcare-associated methicillin-resistant *Staphylococcus aureus* and methicillin-sensitive *Staphylococcus aureus* isolates (N = 291)

Antibiotic	n (%)		P value*
	Resistant MRSA isolates (n = 88)	Resistant MSSA isolates (n = 203)	
Ciprofloxacin	66 (75.0)	68 (33.5)	<0.001†
Clindamycin	45 (51.1)	33 (16.3)	<0.001†
Trimethoprim/sulfamethoxazole	52 (59.1)	59 (29.1)	<0.001†
Erythromycin	55 (62.5)	64 (31.5)	<0.001†
Gentamicin	37 (42.1)	22 (10.8)	<0.001†
Linezolid	0 (0.0)	0 (0.0)	-
Penicillin	88 (100.0)	181 (89.2)	0.001†
Rifampicin	1 (1.1)	0 (0.0)	0.128
Teicoplanin	0 (0.0)	0 (0.0)	-
Tetracycline	33 (37.5)	37 (18.2)	<0.001†

MRSA = methicillin-resistant *Staphylococcus aureus*; MSSA = methicillin-sensitive *Staphylococcus aureus*.

*Determined using the Chi-squared test. †Statistically significant at $P \leq 0.050$.

sensitive *S. aureus* (MSSA) was significantly more frequent in surgical site infections ($P < 0.005$).

The antibiotic resistance patterns of the MRSA and MSSA isolates are shown in Table 2. All of the MRSA and MSSA isolates were susceptible to teicoplanin and linezolid, while the majority of MRSA isolates were resistant to ciprofloxacin (75.0%), clindamycin (51.1%), trimethoprim/sulfamethoxazole (59.1%) and erythromycin (62.5%). In comparison to MSSA isolates, MRSA isolates were significantly more resistant to ciprofloxacin, clindamycin, trimethoprim/sulfamethoxazole, erythromycin, gentamicin and tetracycline ($P < 0.005$).

Of the MRSA strains, 84 (95.5%) were susceptible to vancomycin while four (4.6%) demonstrated intermediate resistance. None of the strains were resistant to vancomycin. The MIC₉₀ and MIC₅₀ values of vancomycin were 2.00 µg/mL and 1.00 µg/mL, respectively. The four MRSA strains with intermediate resistance to vancomycin were isolated from four patients with osteomyelitis, an infected wound, a *psoas* abscess and catheter-associated bacteraemia, respectively; three of the isolates were from patients in a governmental hospital and the remaining isolate was from a patient in a private hospital. Two of the isolates with intermediate resistance to vancomycin were of the cMLS_B phenotype and two were of the

Table 3: Macrolide-lincosamide-streptogramin B phenotypes among patients with healthcare-associated methicillin-resistant *Staphylococcus aureus* infections (N = 88)

Hospital	n (%)		
	cMLS _B phenotype	iMLS _B phenotype	MS _B phenotype
Government hospital 1	6 (6.8)	23 (26.1)	8 (9.1)
Government hospital 2	1 (1.1)	1 (1.1)	0 (0.0)
Private hospital 1	1 (1.1)	4 (4.5)	3 (3.4)
Private hospital 2	2 (2.3)	3 (3.4)	3 (3.4)
Total*	10 (11.4)	31 (35.2)	14 (15.9)

MLS_B = macrolide-lincosamide-streptogramin B; cMLS_B = constitutive MLS_B; iMLS_B = inducible MLS_B; MS_B = macrolide-streptogramin B.

*The remaining 33 isolates were sensitive to both clindamycin and erythromycin.

MS_B phenotype. A total of 10 MRSA isolates (11.4%) were resistant to both erythromycin and clindamycin (cMLS_B phenotype), while 45 (51.1%) were resistant to erythromycin but susceptible to clindamycin. Of these 45 strains, 31 (68.9%) were D-test positive (iMLS_B phenotype) and 14 (31.1%) were D-test negative (MS_B phenotype). The remaining 33 MRSA isolates (37.5%) were sensitive to both clindamycin and erythromycin. The MLS_B phenotypes of the MRSA isolates from the four hospitals are shown in Table 3.

Discussion

Considerable geographical variation exists in the prevalence of healthcare-associated MRSA infections.²⁻⁴ The present study revealed a high cumulative rate of health-associated MRSA infections among patients admitted to four tertiary care hospitals in Mangalore. However, the rate was lower than the 41% national prevalence rate reported by the Indian Network for Surveillance of Antimicrobial Resistance (INSAR) Group based on data collected from 15 tertiary centres.⁸ Nevertheless, the rate in the present study was higher than that reported from the same four hospitals in a previous study in 2011 (25.25%).⁷ Akoğlu *et al.* reported a higher rate of healthcare-associated MRSA in Turkey (71.5%) while the Australian Group on Antimicrobial Resistance reported a similar rate (30.3%) to that of the current study.^{19,20} However, it is important to note that the current study included patients with potential predisposing risk factors to healthcare-associated MRSA infections, including previous surgeries/trauma, the presence of indwelling devices such as catheters and lengthy hospital stays.¹² In terms of gender predilection, no significant difference was found between male and female patients in the

current study; this observation is in agreement with previous research.²¹

A significantly greater number of healthcare-associated MRSA isolates in the current study were resistant to non-β-lactam antibiotics in comparison with healthcare-associated MSSA isolates. A similar observation was made by the INSAR Group.⁸ This could be due to the unique molecular properties of MRSA bacteria—these strains carry the staphylococcal cassette chromosome mec (SCCmec), a mobile genetic element which includes the *mecA* gene that codes for methicillin resistance.²² Healthcare-associated MRSA carries SCCmec types I, II or III; these elements are relatively large and are associated with resistance to many other non-β-lactam antibiotics.²² This kind of multidrug resistance is challenging for clinicians when selecting an appropriate antibiotic for treatment.

Among different phenotypes of MLS_B resistance, detection of cMLS_B does not pose a problem because these strains are resistant to both erythromycin and clindamycin in routine susceptibility testing; however, the detection of iMLS_B and MS_B phenotypes is not possible with standard methods because these strains appear resistant to erythromycin but susceptible to clindamycin.¹⁰ Hence, clindamycin treatment will fail with iMLS_B MRSA strains.¹⁰ Conversely, if clindamycin is not considered as a treatment option due to the suspicion that the strain might be resistant, patients with clindamycin-susceptible infections would be deprived of the correct antibiotic. In the present study, more than a third of the MRSA isolates were of the iMLS_B phenotype; this finding is higher than those reported from previous Indian studies.^{7,23} Studies from other parts of the world have shown iMLS_B phenotype rates ranging from 7.1–56%.^{24–26} These results clearly support the use of a D-test to identify healthcare-associated MRSA strains with iMLS_B resistance.

Vancomycin is considered an appropriate antibiotic for the treatment of serious MRSA infections and its use has increased dramatically over the past 20 years due to the emergence of multidrug-resistant healthcare-associated MRSA.^{9,27} However, the recent emergence of vancomycin-intermediate *S. aureus* (VISA) and vancomycin-resistant *S. aureus* (VRSA) infections has added to the difficulty in selecting the appropriate antibiotic for these bacteria.¹ Several reports of MRSA infections with reduced susceptibility to vancomycin have been reported from France, Japan, Korea, Germany and the USA.²⁷ While VRSA infections are not yet a problem in India, VISA strains have been reported from some centres.^{28,29} There were four VISA cases observed in the present study; however, routine testing does not differentiate between VISA and vancomycin-susceptible strains.^{16,17} In the

present study, it was observed that agar dilution was useful in determining the vancomycin MIC and also contributed to differentiating VISA from vancomycin-susceptible strains. Tandel *et al.* have previously shown that the Etest® (bioMérieux, Marcy-l'Étoile, Lyon, France) can also be used for this purpose.³⁰ Determining the MIC of vancomycin is required before selecting this antibiotic for the treatment of a healthcare-associated MRSA infection. Fortunately, all MRSA strains were susceptible to linezolid, leaving it as the choice of treatment in these cases.

Molecular testing was not performed on the MRSA isolates and was therefore a limitation of the present study. There is an urgent need for further studies on the judicious use of vancomycin and the surveillance of antibiotic resistance. In addition, strategies need to be implemented in order to prevent healthcare-associated infections in India.

Conclusion

A high rate of healthcare-associated MRSA infections was observed, indicating that this type of infection is a significant concern for the four hospitals included in this study. A greater number of MRSA cases were multidrug-resistant as compared with MSSA. A D-test should be performed before selecting clindamycin to treat cases of MRSA that appear susceptible to clindamycin but are resistant to erythromycin according to standard antibiotic susceptibility testing. The MIC of vancomycin should be determined and susceptibility should be proven before considering this antibiotic for the treatment of serious MRSA infections.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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