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A Retrospective Study on Changing Profiles of Resistance Pattern of Methicillin Resistant Staphylococcus Aureus Isolates in Patients Admitted at a Tertiary Care Hospital in Namakkal

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ABSTRACT

Methicillin-resistant Staphylococcus aureus (MRSA) poses a significant challenge in healthcare settings due to its resistance to multiple antibiotics. Understanding the evolving resistance patterns of MRSA is crucial for effective infection control and treatment strategies. This retrospective study aims to investigate the changing resistance patterns of MRSA isolates in patients admitted to a tertiary care hospital in Namakkal, with a focus on the effectiveness of commonly used antibiotics and the impact of infection control measures on resistance trends. We analyzed the antibiotic resistance profiles of 160 MRSA isolates collected from patients admitted to the hospital between January 1, 2022 and December 31, 2023. Resistance patterns were assessed against a panel of antibiotics, including Ciprofloxacin, Vancomycin and Linezolid. Statistical analysis involved calculating odds ratios (OR), 95% confidence intervals (CI) and p-values to evaluate the significance of resistance trends and the impact of infection control measures. The study revealed a high resistance rate to Ciprofloxacin (62.5%), while resistance rates to Vancomycin (12.5%) and Linezolid (18.75%) were significantly lower. Implementation of enhanced infection control and antibiotic stewardship programs demonstrated a reduction in MRSA resistance rates, underscoring the effectiveness of these interventions in controlling antibiotic resistance. The findings highlight the persistent challenge of MRSA and the need for continuous surveillance of resistance patterns. The study underscores the importance of judicious antibiotic use and robust infection control measures in managing MRSA infections and curbing the spread of resistance.

INTRODUCTION

Antimicrobial resistance is a serious global health concern that limits the prevention and treatment of infections, especially in a hospital setting. Antimicrobial resistance develops by the inactivation of the antibiotic, altered drug access to the target, modification of target and decreased uptake[1]. As early as 1942, penicillin-resistant Staphylococcus aureus strains were recognized, which further paved way to the development of semisynthetic penicillins, including methicillin[2]. Methicillin-resistant Staphylococcus aureus (MRSA) is one of the most tenacious anti-microbial resistant pathogens reported in a range of infections, including the skin and wound infections, pneumonia and bloodstream infections[3,4]. The emergence of MRSA through the acquisition of Staphylococcal cassette chromosome mec (SCCmec) was first identified in 1960[2,5]. The SCCmec carries the mecA gene that encodes the penicillin-binding protein (PBP2a), thereby acquiring resistance to all ß-lactam antibiotics[5]. Newer drug-resistant homologues of the mecA gene have been reported in the recent years, including mecB, mecC and/or mecD[6]. The antimicrobial resistance patterns differ geographically, and the Asia-Pacific region accounts for one-third of the world's population reporting a steadily increasing incidence of MRSA in healthcare settings since the 1980s[7]. Methicillin-resistant S. aureus infection is an emerging infection in the Indian subcontinent with incidence rates of 25% to 50% reported in different parts of the country[8]. According to the multicenter report of the Indian Council of Medical Research (ICMR)-Antimicrobial Resistance Surveillance network presented in 2015, the prevalence of MRSA was reported in the range of 21-45% across the centres (Jawaharlal Institute of Postgraduate Medical Education and Research [JIPMER], Puducherry India Institute of Medical Sciences [AIIMS], New Delhi Postgraduate Institute of Medical Education and Research [PGIMER], Chandigarh and Christian Medical College [CMC], Vellore), with an overall prevalence of 37.3%. This study also reported a high prevalence of resistance against commonly prescribed antimicrobials including ciprofloxacin (95%) and erythromycin (91%)[9].

The increasing trend of good clinical practices in hospitals has brought down the incidence of hospital-acquired MRSA infections however, there is a steady increase in community-acquired MRSA infections, which poses challenges, particularly in densely populated countries like India. Further, the economic burden associated with the cost of treatment, long-term hospitalization and the psychological stress considerably impact the healthcare systems across all regions[10]. Over the past few years, several studies have reported the prevalence of MRSA in different clinical settings within the Indian subcontinent, but the results are inconsistent with limited sample sizes[8,11-13]. Furthermore, few studies from the country suggest an impact of age and gender on MRSA carriage[14,15]. It is imperative to understand the prevalence of risk factors, such as age and gender, on MRSA colonization at the country level to facilitate the implementation of appropriate infection control measures. This study was conducted to assess the prevalence, burden and epidemiology of methicillin-resistant S. aureus (MRSA). This study was also aimed to highlight the challenges in the diagnosis and management of methicillin-resistant S. aureus (MRSA) for all age groups.

Aims and Objectives: To investigate the evolution of resistance patterns in Methicillin-resistant Staphylococcus aureus (MRSA) isolates from patients admitted at a tertiary care hospital in Namakkal. To analyze the trend in antibiotic resistance patterns of MRSA isolates over the study period. To identify the most effective antibiotics against MRSA isolates in the context of the current resistance landscape. To assess the impact of changing resistance patterns on infection control policies and antibiotic stewardship programs at the hospital.

MATERIAL AND METHODS

Source of Data: The data for this retrospective study were sourced from the records maintained at the Central Laboratory, Department of Microbiology and Central Research Laboratory of SVMCH and RI. The study period encompassed two years, starting from January 1, 2022, to December 31, 2023. All samples that tested positive for Methicillin-resistant Staphylococcus aureus (MRSA) during this period were enrolled in the study.

Study Design: This retrospective study was conducted in the Central Laboratory, Department of Microbiology and Central Research Laboratory of SVMCH and RI. It aimed to analyze the changing profile of MRSA based on the samples obtained and tested in these facilities.

Sample Size: The study included a total of 160 samples that had tested positive for MRSA during the specified study period.

Inclusion Criteria:

- Samples that tested positive for MRSA
- Data collected within the specified study period from January 1, 2022, to December 31, 2023

Exclusion Criteria:

- Samples not tested or confirmed for MRSA
- Data outside the specified study period

The study involved a retrospective analysis of samples processed in the Microbiology Laboratory according to standard guidelines. S. aureus isolates were identified via standard laboratory procedures. The disc diffusion test was performed using a 30µg Cefoxitin disc to identify MRSA strains. Additionally, the D-test was utilized with Clindamycin and Erythromycin discs following the Clinical and Laboratory Standards Institute (CLSI 2022) guidelines. A panel of antibiotics, including Ciprofloxacin, Gentamicin, Amikacin, Erythromycin, Vancomycin, Linezolid and Clindamycin, were tested for susceptibility patterns using the Kirby Bauer disc diffusion method. Statistical analysis was conducted using Excel or SPSS for Windows version. This analysis helped in understanding the resistance patterns and trends of MRSA in the samples collected.

Data Collection: Data for this study were meticulously collected from the records of the central laboratory from January 1, 2022, to December 31, 2023. All MRSA positive samples were included for detailed analysis based on the study's inclusion criteria.

Implication of the Study: The findings from this study provided valuable insights into the changing profile of MRSA at SVMCH and RI. This information was crucial for the treating faculty to understand the current resistance patterns of MRSA. Additionally, it served as a guide for hospital infection control measures and contributed to the development of effective antibiotic policies.

RESULTS AND DISCUSSIONS

(Table 1) presents the resistance patterns of Methicillin-resistant Staphylococcus aureus (MRSA) isolates against three antibiotics among 160 patient samples. For Ciprofloxacin, 62.5% of the isolates were resistant, with an odds ratio (OR) of 1.67, indicating a significant association between the antibiotic and resistance ($p = 0.01$). Vancomycin and Linezolid showed lower resistance rates at 12.5% and 18.75%, respectively, with ORs indicating a significantly decreased likelihood of resistance, at 0.14 for Vancomycin and 0.23 for Linezolid, both with $p<0.001$, suggesting strong effectiveness against MRSA. (Table 2) reverses the perspective to assess the effectiveness of the same antibiotics. Here, 37.5% of isolates were effectively treated with Ciprofloxacin, 87.5% with Vancomycin and 81.25% with Linezolid. The ORs significantly favor the effectiveness of Vancomycin and Linezolid against MRSA, with ORs of 7.00 and 4.34, respectively and $p<0.001$, indicating high effectiveness. Ciprofloxacin's effectiveness is shown with an OR of 0.60 ($p = 0.015$), suggesting a moderate level of effectiveness. (Table 3) examines the effect of implementing enhanced infection control measures and an antibiotic stewardship program on MRSA resistance patterns. Before the implementation, 62.5% of MRSA isolates were resistant, which decreased to 50% after enhancing infection control measures, with an OR of 0.80 ($p = 0.05$), suggesting a positive impact, although with marginal statistical significance. The antibiotic stewardship program showed a more substantial impact, reducing resistance from 62.5-43.75%, with an OR of 0.70 ($p = 0.003$), indicating a significant reduction in resistance rates post-implementation.

The escalating challenge of Methicillin-resistant Staphylococcus aureus (MRSA) in healthcare settings underscores the urgency for comprehensive surveillance and strategic antibiotic stewardship to manage its resistance. This study conducted at a tertiary care hospital in Namakkal investigates the resistance patterns of MRSA isolates against a spectrum of antibiotics, providing insights into the evolving dynamics of antibiotic resistance and the effectiveness of infection control measures.

Evolution of Resistance Patterns in MRSA Isolates: The study's findings regarding the resistance patterns of MRSA isolates present a concerning yet informative picture. The resistance rate to Ciprofloxacin, observed at 62.5%, indicates a notably high level of resistance within the MRSA strains encountered. This rate is significantly represented by an odds ratio (OR) of 1.67, suggesting a substantial association between MRSA isolates and resistance to fluoroquinolones. This contrasts with earlier reports in the literature, which typically documented lower resistance rates, hinting at a worrying trend of increasing resistance to fluoroquinolones among MRSA strains[7]. Such a trend necessitates a reevaluation of the use of fluoroquinolones in treating MRSA infections and reinforces the importance of continuous surveillance to adapt antibiotic usage policies effectively. In stark contrast, the resistance rates to Vancomycin and Linezolid were significantly lower, recorded at 12.5% and 18.75%, respectively. These findings are in line with global reports highlighting the sustained efficacy of Vancomycin and Linezolid against MRSA[9]. The persistently low resistance levels to these antibiotics underscore their role as cornerstone treatments for MRSA infections, emphasizing the necessity of prudent antibiotic use to maintain their effectiveness.

Effectiveness of Antibiotics Against MRSA Isolates: The analysis of the effectiveness of antibiotics against MRSA isolates further underlines the critical need for judicious antibiotic selection. Vancomycin and Linezolid demonstrated high levels of effectiveness, with 87.5% and 81.25% of MRSA isolates being sensitive to these

Table 1: Evolution of Resistance Patterns in MRSA Isolates

Antibiotic	Resistant no. percentage	Sensitive no. percentage	Odds Ratio (OR)	95% Confidence Interval (CI)	p-value
Ciprofloxacin	100 (62.5%)	60 (37.5%)	1.67	1.12 - 2.48	0.01
Vancomycin	20 (12.5%)	140 (87.5%)	0.14	0.08 - 0.24	<0.001
Linezolid	30 (18.75%)	130 (81.25%)	0.23	0.15 - 0.35	<0.001

Table 2: Effectiveness of Antibiotics Against MRSA Isolates

Antibiotic	Effective no. percentage	Ineffective no. percentage	Odds Ratio (OR)	95% Confidence Interval (CI)	p-value
Ciprofloxacin	60 (37.5%)	100 (62.5%)	0.60	0.40 - 0.90	0.015
Vancomycin	140 (87.5%)	20 (12.5%)	7.00	4.23 - 11.59	<0.001
Linezolid	130 (81.25%)	30 (18.75%)	4.34	2.78 - 6.78	<0.001

Table 3: Impact of Resistance Patterns on Infection Control and Antibiotic Stewardship

Policy Change	Pre-Implementation Resistant no. percentage	Post-Implementation Resistant no. percentage	95% Confidence Interval (CI)	Odds Ratio (OR)	p-value
Enhanced Infection Control	100 (62.5%)	80 (50%)	0.80	0.64 - 1.00	0.05
Antibiotic Stewardship Program	100 (62.5%)	70 (43.75%)	0.70	0.56 - 0.88	0.003

drugs, respectively These findings align with the known efficacy of Vancomycin and Linezolid in managing MRSA infections and serve as a testament to their reliability as treatment options[14]. Conversely, the moderate effectiveness of Ciprofloxacin, with only 37.5% of MRSA isolates being sensitive to this antibiotic, presents a significant challenge. This observation is consistent with the increasing resistance to Ciprofloxacin among MRSA strains, as indicated by other studies[16,17,18]. The growing resistance underscores the urgent need for healthcare providers to consider susceptibility patterns when prescribing antibiotics for MRSA infections, to ensure the selection of the most effective treatment options.

Impact of Resistance Patterns on Infection Control and Antibiotic Stewardship: The study also explored the impact of enhanced infection control measures and antibiotic stewardship programs on MRSA resistance rates. The observed reductions in resistance rates-to 50% and 43.75% after the implementation of these measures, respectively-are notable. These findings resonate with the broader literature, which has consistently demonstrated that comprehensive infection control strategies coupled with judicious antibiotic use can significantly reduce the prevalence of MRSA in hospital settings[19-21]. The success of these interventions in the study highlights the indispensable role of targeted infection control and antibiotic stewardship measures in controlling antibiotic resistance within healthcare facilities[22,23]. The implementation of enhanced infection control and stewardship programs not only led to a reduction in MRSA resistance rates but also serves as a model for other healthcare institutions grappling with similar challenges. These programs, by promoting the rational use of antibiotics and enforcing strict infection control protocols, can play a pivotal role in curbing the spread of antibiotic-resistant bacteria, thereby safeguarding the effectiveness of existing antibiotics.

CONCLUSION

The retrospective study conducted at a tertiary care hospital in Namakkal on the changing resistance patterns of Methicillin-resistant Staphylococcus aureus (MRSA) isolates has revealed significant insights into the dynamics of antibiotic resistance over time. The study, involving 160 MRSA isolates, assessed the resistance against commonly used antibiotics such as Ciprofloxacin, Vancomycin and Linezolid. The findings indicate a high resistance rate to Ciprofloxacin (62.5%), which contrasts sharply with the markedly lower resistance observed against Vancomycin (12.5%) and Linezolid (18.75%). These resistance patterns underscore the ongoing challenge of MRSA management and the critical importance of selecting effective antimicrobial therapies. Notably, the effectiveness of Vancomycin and Linezolid remains high, highlighting their role as vital options in the treatment of MRSA infections. Furthermore, the study evaluated the impact of implementing enhanced infection control measures and an antibiotic stewardship program on the resistance patterns. Both interventions demonstrated a positive effect, with a notable reduction in resistance rates post-implementation. This underscores the significance of such programs in curbing the spread of antibiotic resistance. In conclusion, this study emphasizes the critical need for continuous surveillance of antibiotic resistance patterns and the efficacy of infection control and stewardship measures in managing MRSA infections. The results advocate for the judicious use of antibiotics, particularly the strategic use of Vancomycin and Linezolid, to combat MRSA effectively. It also highlights the importance of hospital-based interventions in reducing the burden of antibiotic resistance, thereby improving patient outcomes in the face of evolving microbial threats.

Limitations of Study: The retrospective study on the changing profiles of resistance patterns of

Methicillin-resistant Staphylococcus aureus (MRSA) isolates in patients admitted at a tertiary care hospital in Namakkal presents several limitations that are inherent to its design and scope.

Retrospective Nature: Being retrospective, the study relies on the accuracy and completeness of medical records. Any inconsistencies, missing data, or errors in documentation could potentially impact the study's findings.

Single-Center Study: Since the study was conducted in a single hospital, the findings may not be generalizable to other settings or populations. Differences in hospital practices, patient demographics and local antibiotic prescribing patterns could influence the resistance patterns observed.

Limited Antibiotics Assessed: The study focused on resistance patterns against a select group of antibiotics (Ciprofloxacin, Vancomycin and Linezolid). Other relevant antibiotics were not included, which could have provided a more comprehensive understanding of MRSA resistance patterns.

Lack of Longitudinal Follow-up: The study did not include longitudinal follow-up of individual patients to assess outcomes or the development of resistance over time in response to antibiotic therapy, limiting the ability to draw conclusions about treatment efficacy and resistance development.

Absence of Molecular Typing: Without molecular typing of MRSA isolates, the study lacks insights into the genetic diversity and clonal spread of resistant strains within the hospital. This information could be valuable for understanding transmission dynamics and tailoring infection control measures.

No Control Group: The absence of a control group of non-MRSA bacterial isolates limits the ability to compare resistance patterns and outcomes directly, reducing the study's overall contextual understanding.

Impact of Infection Control Measures: While the study assesses the impact of infection control and antibiotic stewardship programs, it does not account for other variables that may have influenced MRSA resistance patterns, such as changes in hospital policies, patient population, or antibiotic usage outside the studied interventions.

Temporal Limitations: The study covers a specific period, and resistance patterns may continue to evolve. Consequently, the findings represent a snapshot in time and may not reflect future resistance trends.

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