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Original Research Article

Staphylococcus aureus: prevalence and shifting antibiotic landscape in clinical samples from a tertiary care hospital

Surabbhi Anand[1], Pragyan Swagatika Panda[1]*, Bonnie Joe Thomas[1], Kanak Vats[1], Mehvash Haider[1], Dabet Rynga[2]

[1]Department of Microbiology, Vardhaman Mahavir Medical College and Safdarjung Hospital, New Delhi, India
[2]Department of Microbiology, North Eastern Indira Gandhi Regional Institute of Health and Medical Sciences, Mawdiangdiang, Shillong, Meghalaya, India

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***Correspondence:**
Dr. Pragyan Swagatika Panda,
E-mail: pragyanpanda2006@gmail.com

ABSTRACT

Background: *Staphylococcus aureus* is a versatile pathogen causing myriads of detrimental infections in both hospital-acquired and community-acquired settings with its notorious ability to develop antimicrobial resistance (AMR). As the world is battling the persistent rise in antimicrobial resistance (AMR), MRSA (Methicillin-resistant *Staphylococcus aureus*) is a major concern. Adequate data and information about evolving landscape of antibiotic resistance in *S. aureus* is essential for effective interventions to contain the global crisis of AMR.
Methods: A total of 1545 isolates of *S. aureus* from various clinical samples received from January 01, 2023 to December 31, 2023 in a tertiary care hospital were screened for their antibiotic susceptibility pattern (AST). AST was performed by Kirby Bauer Disc diffusion and MIC determination by VITEK 2 AST system and interpretation done as per CLSI M100-S33, 2023 guidelines.
Results: Out of 30,000 clinical samples received and 21% culture positives, *S. aureus* was found in 5.15% (1545) of cases with 62% being MRSA. A predominance in 20-30 years with female preponderance seen. Cotrimoxazole (82%) was the most effective antibiotic, followed by gentamicin (78%) and clindamicin (71%). While penicillin resistance stood at 96%, and ciprofloxacin reached 91%.
Conclusions: A constant shift is resistance pattern with rising prevalence of MRSA isolates, makes it imperative to customize the treatment protocols as per the healthcare specific antibiogram. Continual screening for *S. aureus* infections and analysing its antibiotic profile is mandatory to update clinicians on effective clinical management, preventing prolonged hospitalization, compromised patient outcomes, and increased burden on healthcare expenses.

Keywords: Antimicrobial resistance, Methicillin resistance *Staphylococcus aureus,* Hospital acquired infections

INTRODUCTION

Staphylococcus aureus nicknamed as the “golden staph”, was first identified by Sir Alexander Ogston in the late 19th century. Since then, its path has been marked by milestones of both triumph and tribulation, from the development of antibiotics heralded as miracle drugs to the emergence of resistant strains that challenge the very foundations of modern medicine.[1]

A master of adaptation, *Staphylococcus aureus* has established itself as a ubiquitous inhabitant of the human microbiota. From the tip of the nose to the depths of the gastrointestinal tract, it finds refuge in skin and mucous

membranes, often coexisting peacefully with its human host.[2]Yet, this seemingly benign relationship can quickly take a sinister turn, as *Staphylococcus aureus* seizes the opportunity to exploit vulnerabilities and instigate infections, both in the community and within healthcare settings. It is a leading causative agent in pneumonia and other respiratory tract infections, surgical sites, prosthetic joints, and cardiovascular infections, as well as nosocomial bacteremia.[3]

Penicillin once heralded the miracle drug for its management offered interim relief as β-lactamase gene blaZ lead to resistance in the 1940s. About 1960 saw the development of the first semi-synthetic anti-staphylococcal penicillins, and a year after their initial clinical application, methicillin-resistant S. aureus (MRSA) was discovered. Ironically despite the discovery of several antibiotics, *S. aureus* remains a notorious pathogen to treat with widespread prevalence.[4]

The 2022 Global Antimicrobial Resistance and Use Surveillance System (GLASS) report highlights alarming resistance rates among prevalent bacterial pathogens. Median reported rates in 76 countries of 35% for methicillin-resistant *Staphylococcus aureus* is a major concern.[5]

Staphylococcus aureus is a virulent organism that has shown resistance over the years to beta-lactams, sulphonamides, and tetracyclines. The increasing prevalence of MRSA is a major healthcare concern. Addressing the prevalence of antibiotic resistance in *S. aureus* requires a multifaceted approach, including judicious antibiotic use, infection control measures, development of new antibiotics, and vaccination strategies. Surveillance programs play a crucial role in monitoring the prevalence and trends of antibiotic-resistant *S. aureus* strains, guiding treatment strategies, and public health interventions. Additionally, fostering antimicrobial stewardship programs aimed at promoting appropriate antibiotic use and minimizing the emergence of resistance is essential for preserving the effectiveness of available antibiotics in combating *S. aureus* infections. Thus, the aim of the current study was to identify and determine the antibacterial susceptibility pattern of *Staphylococcus aureus* isolated from various clinical samples.

METHODS

The present study was a retrospective 1-year study from January 01, 2023 to December 31, 2023. Approximately 30,000 clinical samples of pus and wound swabs, respiratory samples (sputum, bronchoalveolar lavage, tracheal aspirate), obstetric and gynaecological samples (cervical/ vaginal swab and placenta), and tissue samples received in the Bacteriology section of the Department of Microbiology, in a tertiary care centre in New Delhi were analysed

Convenience sampling technique was followed as these samples were received as requested by physicians/ surgeons of the entire hospital. All mentioned clinical samples received in the bacteriology section were received from OPD and wards for aerobic culture and sensitivity testing during the period of study.

Inclusion criteria

All samples received from all the departments of the hospital for aerobic culture and sensitivity testing.

Exclusion criteria

Anaerobic culture and samples from ICU.

Ethical consideration

The study was done after obtaining ethical clearance from the institutional committee with reference number IEC/VMMC/SJH/Cert./05-2024/60.

The samples were processed and cultured on MacConkey's and Sheep blood agar. Isolates were identified as per standard microbiologic technique. AST was performed by Kirby Bauer Disc diffusion and MIC determination by VITEK 2 AST system (wherever and whenever feasible) and interpretation was done as per CLSI M100-S33, 2023 guidelines.

RESULTS

Out of the total culture positives (21% of total samples cultured), *Staphylococcus aureus* was found to be positive in 5.15% (1545) of total samples (30, 000). It was mostly isolated from the 20-30 year age group with a female preponderance (Figure 1).

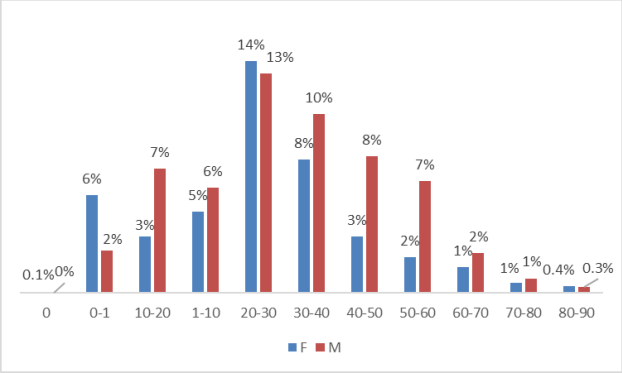

Figure 1: Population demography.

Amongst the diverse range of samples received, *S. aureus* was most commonly isolated from pus and wound swabs (1350 out of 1541). Most of the isolates were obtained from samples from Orthopaedics (435), and Surgery (253), followed by the Department of Obstetrics and Gynaecology (248) (Figure 2).

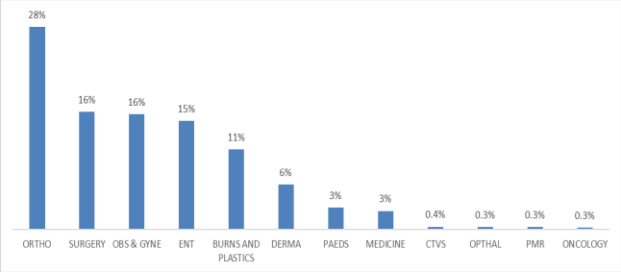

Figure 2: Department distribution.

A steep 62% of the isolates were methicillin-resistant whereby 63% of them were isolated from the outpatient department. The highest MRSA isolates were from the Department of Orthopaedics (66%), and Obstetrics and Gynaecology (65%), followed by the Department of Burns and Plastics (61%).

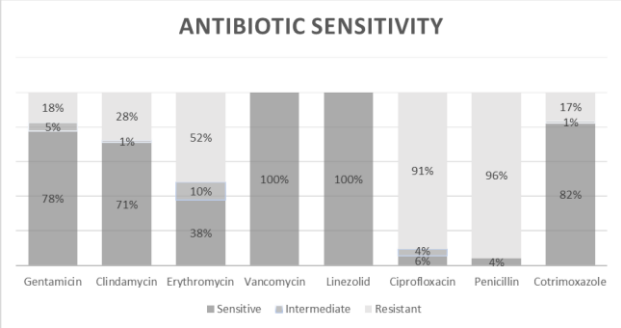

Figure 3: Antibiotic sensitivity results.

Antibiotic susceptibility testing data for penicillin, erythromycin,, gentamicin, co-trimoxazole, gentamicin, ciprofloxacin, vancomycin, and linezolid were compiled (Figure 3). There was no resistance documented against vancomycin and linezolid. Cotrimoxazole was found to be the most effective antibiotic (82% sensitivity) with an astounding 88% in MSSA and 78% in MRSA isolates. This was followed by gentamicin (78% sensitivity) and clindamycin (71% sensitivity). Ninety-six percent of isolates were resistant to penicillin, and a similar high 91% showed resistance to ciprofloxacin. Only 38% of the isolates were sensitive to erythromycin.

DISCUSSION

Among Gram-positive pathogens, *Staphylococcus aureus* continues to be a significant contributor to both skin and soft tissue infections (SSTI) in the community setting and more severe, invasive infections in hospitalized patients.

Various studies have demonstrated varying resistance patterns increasing MRSA strains and reduced sensitivity to vancomycin, thus region-specific studies are imperative to build antibiograms and guide clinicians on empirical therapy and treatment protocols for better health outcomes.

In 2022, a systematic review and meta-analysis reported the prevalence of MRSA approximately 37%, from 2015-2019 in India.[7] MRSA in ICUs leads to poor outcomes and strains infection control efforts. The ICU serves as a hub for MRSA transmission due to patient transfers. ICU patients, especially in surgical units, face heightened infection risks due to wounds and invasive devices.[8]

Joshi et al in their study on Methicillin-resistant *Staphylococcus aureus* (MRSA) in India: Prevalence & susceptibility pattern on 26,310 isolates found an overall prevalence of 41 percent of MRSA.[8] Susceptibility to ciprofloxacin was low and MSSA isolates showed higher susceptibility to gentamicin, cotrimoxazole, erythromycin, and clindamycin, and none of the isolates were found to be resistant to vancomycin or linezolid.

Mohanty et al in their study on the Recent pattern of antibiotic resistance in *Staphylococcus aureus* clinical isolates in Eastern India and the emergence of reduced susceptibility to vancomycin, found the highest resistance to penicillin, followed by erythromycin and ciprofloxacin and 88 percent sensitivity to vancomycin and approx. 12 percent showed reduced sensitivity to vancomycin - including VISA and hVISA.[9]

Our study has revealed a staggering 62% methicillin resistance causing high concern, especially when 63% of isolates were from the out-patient department. A meta-analysis study reveals the pooled prevalence of MRSA in India at 37% (95% CI: 32-41) during 2015-2020.[7] This number is already higher compared to the Western world where a Europe-wide survey, the most common organisms in SSTIs were *S. aureus* (71% cases) with 22.5 percent being MRSA.[10] In A study done in the US spanning over 10 years, there was an overall increasing incidence of *S. aureus* was found, with an increase in community-onset MRSA SSTI.[11]

Methicillin-resistant *S. aureus* can boom for months in a hostile environment and is thereby transmitted from surfaces for prolonged period. A battery of potent virulence factors backs to the success of *S. aureus* as a pathogen. Biofilm formation along with high virulence factors, community spread, overuse, and misuse of antibiotics are major reasons for rising MRSA.[12,13]

Lately, healthcare facilities engrossed on the control of healthcare-associated MRSA (HA-MRSA) lineages, which are poorly adapted for persistence in the community. A vital shift has occurred with the emergence of community-associated MRSA (CA-MRSA), that colonize young and healthy population for prolonged periods. CA-MRSA is also now displacing previously dominant HA-MRSA lineages. The Health care workers playing as the agents of cross transmission as they are at the interface between the hospital and the community.[14]

Penicillin; once a miracle drug for *S. aureus* was found to be most ineffective with 96% resistance. Ciprofloxacin a

commonly used fluoroquinolone also revealed 91% resistance. This highlights the consideration for change in empirical antibiotic prescribing and an urgency to cater to a local antibiogram. A study on trends in antibiotic use among outpatients in New Delhi, India reveals cephalosporins, fluoroquinolones, and penicillin agents were the most prescribed agents while the older antibiotics such as cotrimoxazole and tetracyclines, were infrequently used.[15]

However, in our study, cotrimoxazole was found to be the most effective antibiotic (82.2%). An older gun in the antibiotic arsenal, often undermined showed higher sensitivity and its low cost makes it more efficacious. With 88 % sensitivity in MSSA and 78% in MRSA cases, it urges us to relook at our antibiotic prescribing practices. While it has limitations in usage amongst neonates, pregnant females, megaloblastic anaemia due to folate deficiency and cases of known hypersensitivity, it is not a forgotten drug and careful assessment of patient profile along with sensitivity patterns can be helpful in prescribing this old yet gold drug in case of *S. aureus* infections.

Gentamicin, a parenteral aminoglycoside with synergistic benefits with other antibiotics showed a sensitivity of 78 percent. The concerns of nephrotoxicity and route of administration may find its limitations in prescribing practices.

Clindamycin can be administered orally or intravenously, making it versatile for outpatient and inpatient settings. Clindamycin a lincosamide is effective against MSSA and some MRSA strains. Due to its good tissue penetration, including into bone and abscesses, a sensitivity pattern of 71% makes it particularly useful for deep-seated infections. Erythromycin showed a high resistance of 52 % with 38% resistance and remaining 10% in intermediate category. Erythromycin induced resistance to clindamycin was also noted to avoid therapeutic failure.

All the isolates were found to be sensitive to vancomycin and Linezolid. A glycopeptide that is of great value, especially in cases of MRSA infections, Vancomycin should be reserved in serious infections when other options are not available or else slowly rising cases of resistance (VRSA) and intermediate (VISA) will soon become a nightmare. Vancomycin also requires therapeutic drug monitoring due to nephrotoxicity and ototoxicity. Linezolid is a potent and versatile antibiotic for treating resistant *Staphylococcus aureus* infections, including MRSA and VRSA. Its ability to be administered orally and intravenously, coupled with its excellent tissue penetration, makes it a valuable option in various clinical settings. A comparatively costlier antibiotic, proper stewardship is essential to preserve its effectiveness and prevent the development of resistance.

This study has few limitations. A retrospective study design made it difficult to retrieve clinical details of the patient and molecular identification of isolates and identification of resistant genes was not done.

CONCLUSION

There is a constant shift in resistance pattern with rising prevalence of MRSA isolates causing prolonged hospitalization, compromised patient outcomes, and increased burden on healthcare expenses. This mandates constant screening for *S. aureus* infections and analysis of its antibiotic profile. Infection control practices are fundamental in preventing the transmission of this versatile pathogen. Concurrently, antibiotic stewardship is vital to combat this bacterium's growing resistance to antibiotics. The creation of local antibiograms, which detail the susceptibility patterns in specific healthcare facilities empowers clinicians with precise data and guides the selection of antibiotics, ensuring that therapies are both effective and tailored to the local resistance landscape. It is an imperative step in the battle against Antimicrobial Resistance which is an impending global health crisis.

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Ethical approval: The study was approved by the Institutional Ethics Committee (reference number IEC/VMMC/SJH/Cert./05-2024/60)

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