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ANTIMICROBIAL RESISTANCE AND MULTIDRUG-RESISTANCE PATTERNS AMONG BACTERIAL ISOLATES FROM POST-CAESAREAN SURGICAL SITE INFECTIONS IN WESTERN RAJASTHAN

Medical Microbiology

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ABSTRACT

Background: Antimicrobial resistance among pathogens causing post-caesarean surgical site infection (SSI) compromises empirical therapy and increases maternal morbidity. This study evaluated organism-specific resistance, methicillin resistance and multidrug resistance among bacterial isolates from post-LSCS SSI. **Methods:** In this hospital-based cross-sectional observational study, 550 deep-wound specimens from women aged 18–45 years with clinically suspected SSI within 30 days of LSCS were processed by standard aerobic culture. Identification was performed by conventional methods. Antimicrobial susceptibility was tested by Kirby–Bauer disc diffusion according to applicable CLSI criteria; cefoxitin was used for detection of methicillin resistance.**Results:** Of 550 specimens, 276 (50.2%) yielded significant bacterial growth. Gram-positive cocci comprised 193 (69.9%) isolates and Gram-negative bacilli 83 (30.1%). CoNS (116; 42.0%) and Staphylococcus aureus (61; 22.1%) predominated. Methicillin resistance occurred in 35/61 (57.4%) S. aureus and 71/116 (61.2%) CoNS isolates. All tested Gram-positive isolates were susceptible to vancomycin and linezolid. Overall, 236/276 (85.5%) isolates were multidrug resistant.**Conclusion:** The high prevalence of methicillin resistance and multidrug resistance among post-caesarean SSI isolates warrants culture-guided therapy, periodic institutional antibiograms, antimicrobial stewardship and strengthened infection-prevention practices.

KEYWORDS

Antimicrobial Resistance; Multidrug Resistance; Surgical Site Infection; Caesarean Section; Mrsa; Mr-cons; Antibiogram.

INTRODUCTION

Surgical site infection following caesarean delivery is an important healthcare-associated infection that prolongs recovery, increases resource utilization and may progress to severe maternal complications. [1,2,3]

Increasing caesarean delivery rates have expanded the number of women exposed to postoperative infection, particularly in resource-constrained settings where surveillance and infection-prevention capacity may be variable. [4,5,6]

The microbiology of post-caesarean SSI includes staphylococci, Enterobacterales, enterococci and non-fermenting Gram-negative bacilli. The distribution is institution specific and is influenced by maternal flora, referral patterns, antimicrobial exposure and the healthcare environment. [7,8,9,10]

Antimicrobial resistance has made empirical treatment increasingly difficult. Methicillin-resistant staphylococci, extended-spectrum beta-lactamase-producing Enterobacterales and carbapenem-resistant organisms reduce therapeutic options and may be associated with treatment failure and prolonged hospitalization. [11,12,13,14]

Standardized susceptibility testing, local antibiograms and antimicrobial stewardship are therefore essential for rational empirical therapy and timely de-escalation. [15,16,17]

The present analysis was undertaken to characterize antimicrobial resistance, methicillin resistance and the overall burden of multidrug resistance among bacterial isolates recovered from post-LSCS SSI in a tertiary-care centre in western Rajasthan.

AIM AND OBJECTIVES

Aim

To evaluate the antimicrobial resistance and multidrug-resistance patterns among bacterial isolates recovered from surgical site infections following lower segment caesarean section at a tertiary-care centre in western Rajasthan.

Objectives

1. To determine the antimicrobial susceptibility pattern of bacterial isolates recovered from post-caesarean surgical site infections.
2. To determine the prevalence of methicillin-resistant Staphylococcus aureus (MRSA) and methicillin-resistant coagulase-negative staphylococci (MR-CoNS).
3. To estimate the overall burden of multidrug resistance among the bacterial isolates.
4. To assess the clinical implications of the observed resistance pattern for empirical therapy and antimicrobial stewardship.

MATERIALS AND METHODS

Study design and setting: This hospital-based cross-sectional observational study was conducted from April 2024 to March 2026 in the Department of Microbiology, Dr. S. N. Medical College and Associated Group of Hospitals, Jodhpur, Rajasthan.

Study population and sampling: Women aged 18–45 years with clinically suspected SSI within 30 days after LSCS were enrolled consecutively. A total of 550 eligible deep-wound specimens were included. Unlabelled, leaking, dried, contaminated, delayed, duplicate or otherwise unsuitable specimens were excluded.

Inclusion criteria

- Written informed consent obtained.
- An appropriate deep-wound specimen received for microbiological examination.
- Clinically suspected surgical site infection occurring within 30 days after lower segment caesarean section.
- Women aged 18–45 years.

Exclusion criteria

- Patients who did not provide written informed consent.
- Duplicate or otherwise unsuitable specimens.
- Leaking, dried, visibly contaminated or delayed specimens.
- Unlabelled or improperly labelled specimens.

Microbiological processing: Aspirated pus was preferred; when aspiration was not feasible, two deep-wound swabs were collected after cleaning the wound and before antimicrobial therapy whenever possible. Direct Gram staining was performed. Specimens were inoculated on blood agar and MacConkey agar and incubated aerobically at 35–37°C for 18–24 hours. Isolates were identified by

colony morphology, Gram reaction and standard biochemical tests.

Antimicrobial susceptibility testing: A 0.5 McFarland suspension was tested by the Kirby–Bauer disc-diffusion method on Mueller–Hinton agar. Zone diameters were interpreted according to applicable CLSI criteria. Methicillin resistance in staphylococci was detected by the cefoxitin-disc method, with appropriate quality-control strains. 15,16

Data analysis:

Frequencies and percentages were used to summarize organism distribution and susceptibility results. Multidrug resistance was classified according to the operational definition applied in the thesis.

RESULTS

Significant bacterial growth was obtained from 276/550 (50.2%) specimens. Gram-positive organisms accounted for 193/276 (69.9%) isolates and Gram-negative organisms for 83/276 (30.1%). CoNS were the predominant isolates, followed by S. aureus; E. coli and K. pneumoniae were the leading Gram-negative pathogens.

Table 1. Distribution of bacterial isolates among culture-positive samples (n=276)

Organism	Number of isolates	Percentage (%)
Coagulase-negative Staphylococcus (CoNS)	116	42.0
Staphylococcus aureus	61	22.1
Klebsiella pneumoniae	33	12.0
Escherichia coli	33	12.0
Enterococcus species	16	5.8
Pseudomonas aeruginosa	11	4.0
Citrobacter species	6	2.2
Total	276	100.0

Table 2. Methicillin resistance among staphylococcal isolates

Organism	Tested (n)	Methicillin-resistant n (%)	Methicillin-sensitive n (%)
Staphylococcus aureus	61	35 (57.4)	26 (42.6)
Coagulase-negative Staphylococcus	116	71 (61.2)	45 (38.8)

Table 3. Summary of antimicrobial resistance among bacterial isolates

Rank	Gram-positive antibiotic	Resistance (%)	Gram-negative antibiotic	Resistance (%)
1	Ampicillin	87%	Cotrimoxazole	84%
2	Azithromycin	64%	Amox-clav	79%
3	Amox-clav	61%	Gentamicin	66%
4	Ciprofloxacin	61%	Ceftazidime	59%
5	Cefoxitin	60%	Ciprofloxacin	58%
6	Cotrimoxazole	59%	Cefepime	49%
7	Gentamicin	47%	Doxycycline	36%
8	High-level gentamicin	38%	Pip-tazo	33%
9	Doxycycline	37%	Amikacin	30%
10	Amikacin	35%	Meropenem	19%
11	Vancomycin	1%	—	—
12	Linezolid	0%	—	—

Table 4. Overall burden of multidrug resistance among bacterial isolates (N=276)

Susceptibility result	Number	Percentage (%)
Multidrug-resistant (MDR)	236	85.5
Non-MDR	40	14.5
Total isolates	276	100.0

Methicillin resistance was detected in 57.4% of S. aureus and 61.2% of CoNS isolates. All tested Gram-positive isolates retained susceptibility to vancomycin and linezolid. Overall, 236 isolates (85.5%) were multidrug resistant, demonstrating a substantial resistance burden.

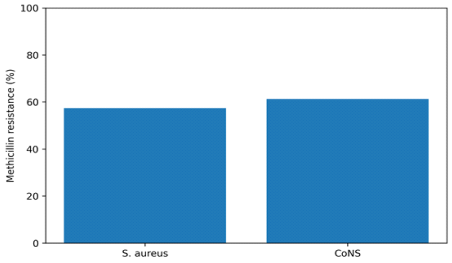

Figure 1. Methicillin resistance among Staphylococcus aureus and coagulase-negative staphylococci.

Clinical interpretation:

The resistance profile indicates that commonly used empirical agents may be unreliable in a substantial proportion of post-caesarean SSI cases. The high frequency of MRSA, MR-CoNS and MDR isolates supports early deep-wound culture, susceptibility-guided de-escalation and periodic revision of the institutional antibiogram. Vancomycin and linezolid should remain reserved for microbiologically supported indications rather than routine empirical use.

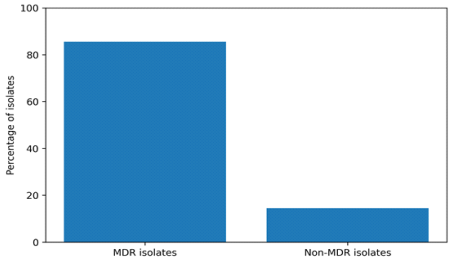

Figure 2. Overall burden of multidrug resistance among bacterial isolates (n=276).

DISCUSSION

The present study demonstrated a high burden of antimicrobial resistance among bacterial isolates from post-caesarean SSI. Staphylococci predominated, and more than half of both S. aureus and CoNS isolates were methicillin resistant. Similar concerns regarding resistant staphylococci in surgical and obstetric wounds have been reported from Indian healthcare settings. [8,10,11,18]

The predominance of CoNS should be interpreted in the context of appropriate deep-wound sampling and compatible clinical findings. Although these organisms are components of normal skin flora, their biofilm-forming capacity and increasing methicillin resistance can make them clinically relevant in postoperative infection. [7,19,20]

E. coli and K. pneumoniae were the principal Gram-negative isolates. Their resistance to commonly used beta-lactams and frequent co-resistance to other antimicrobial classes may be driven by extended-spectrum beta-lactamases and other acquired mechanisms. [12,13,21,22]

The overall MDR prevalence of 85.5% is a major therapeutic concern. Prior antimicrobial exposure, empirical broad-spectrum prescribing, prolonged healthcare contact and cross-transmission can select and sustain resistant strains. Culture collection before treatment and prompt susceptibility-guided de-escalation are important components of stewardship. [17,23,24,25]

The complete in-vitro activity of vancomycin and linezolid against the tested Gram-positive isolates is reassuring; however, these reserve agents require judicious use to preserve their effectiveness. Local treatment protocols should be based on periodically updated cumulative antibiograms rather than extrapolated from other institutions. [15,16,17,26]

Prevention of SSI and containment of resistance require coordinated action: correct timing and selection of surgical prophylaxis, hand hygiene, aseptic technique, standardized wound care, surveillance with feedback, environmental infection control and antimicrobial stewardship. [27,28,29,30]

This study provides contemporary resistance data from a tertiary-care centre in the semi-arid zone of western Rajasthan and may assist local clinicians in refining empirical treatment while awaiting culture results.

PRACTICAL IMPLICATIONS FOR ANTIMICROBIAL STEWARDSHIP

The study supports a diagnostic-stewardship pathway in which an appropriate deep-wound specimen is obtained before antibiotics whenever clinically feasible, empirical therapy is selected using the current institutional antibiogram, and treatment is narrowed after culture and susceptibility results. Repeated use of reserve agents without microbiological evidence should be avoided. The local antibiogram should be updated periodically and discussed jointly by microbiology, obstetrics, infection-control and antimicrobial-stewardship teams.

CONCLUSION

Post-caesarean SSI isolates showed a high prevalence of methicillin resistance and multidrug resistance. MRSA and MR-CoNS were common, while vancomycin and linezolid retained activity against tested Gram-positive isolates. Routine culture and susceptibility testing, periodic institutional antibiograms, antimicrobial stewardship and rigorous infection-prevention practices are necessary to improve maternal outcomes and limit further emergence of resistance.

LIMITATIONS

This was a single-centre study restricted to aerobic bacterial culture. Anaerobic and fungal pathogens were not routinely evaluated, and molecular characterization of resistance determinants was not performed. Prior antimicrobial exposure may have affected culture yield. The findings should therefore be interpreted within the local institutional context.

DECLARATIONS

Ethical approval

Ethical approval was obtained from the Institutional Ethics Committee, Dr. Sampurnanand Medical College, Jodhpur, Rajasthan, India (Certificate Reference No. SNMC/IEC/2026/Plan/1308; dated 01 May 2026). Written informed consent was obtained from all participants, and participant confidentiality was maintained throughout the study.

Informed consent

Written informed consent was obtained from all participants.

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Conflict of interest

The authors declare no conflict of interest.

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Author contributions

Dr Prinka Choudhary: investigation, data collection, laboratory work and initial drafting. Dr Richa Bareth: manuscript preparation, review, editing and correspondence. Dr R. S. Parihar: conception, supervision and critical revision. Dr Mukesh: methodology support, interpretation and critical review. Dr Mukesh Sharma: critical review of the manuscript and approval of the final version.

Citation audit completed: all 30 references are cited; new references are numbered in first-appearance order; repeated references retain their original number.

REFERENCES

1. Calderwood MS, Anderson DJ, Bratzler DW, Dellinger EP, Garcia-Houchins S, Maragakis LL, et al. Strategies to prevent surgical site infections in acute-care hospitals: 2022 update. Infect Control Hosp Epidemiol. 2023 May;44(5):695–720. Available from: https://doi.org/10.1017/ice.2023.67
2. Allegranzi B, Nejad SB, Combescure C, Graafmans W, Attar H, Donaldson L, et al. Burden of endemic health-care-associated infection in developing countries: systematic review and meta-analysis. Lancet. 2011 Jan 15;377(9761):228–41. Available from: https://doi.org/10.1016/S0140-6736(10)61458-4
3. World Health Organization. Report on the burden of endemic health care-associated infection worldwide [Internet]. Geneva: WHO; 2011 [cited 2026 Jun 8]. Available from: https://www.who.int/publications/i/item/report-on-the-burden-of-endemic-health-care-associated-infection-worldwide
4. World Health Organization. Global guidelines for the prevention of surgical site infection [Internet]. Geneva: WHO; 2016 [cited 2026 Jun 8]. Available from: https://www.who.int/publications/i/item/9789241550475
5. Mengistu DA, Alemu A, Abdukadir AA, Mohammed Husen A, Ahmed F, Mohammed B, et al. Global incidence of surgical site infection among patients: systematic review and meta-analysis. Inquiry. 2023 Mar 25;60:00469580231162549. Available from: https://doi.org/10.1177/00469580231162549
6. Sung S, Mikes BA, Martingano DJ, Mahdy H. Cesarean delivery. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2026 [cited 2026 Jun 8]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK546707/
7. Betran AP, Ye J, Moller AB, Souza JP, Zhang J. Trends and projections of caesarean section rates: global and regional estimates. BMJ Glob Health. 2021 Jun;6(6):e005671. Available from: https://doi.org/10.1136/bmjgh-2021-005671
8. Saeed KBM, Greene RA, Corcoran P, O'Neill SM. Incidence of surgical site infection following caesarean section: a systematic review and meta-analysis protocol. BMJ Open. 2017;7(1):e013037. Available from: https://doi.org/10.1136/bmjopen-2016-013037
9. Thakur N, Kujur A. Microbiological and antibiotic sensitivity pattern of surgical site infection following caesarean section in a tertiary care center of Chhattisgarh. Int J Reprod Contracept Obstet Gynecol. 2021 Jun 28;10(7):2638–46. Available from: https://doi.org/10.18203/2320-1770.ijrcog20212369
10. Prevalence, risk factors and microbial profile of surgical site infection after cesarean section in a tertiary care center in western India. J Pure Appl Microbiol [Internet]. 2022 [cited 2026 Jun 9]. Available from: https://microbiologyjournal.org/prevalence-risk-factors-and-microbial-profile-of-surgical-site-infection-after-cesarean-section-in-a-tertiary-care-center-in-western-india/
11. Mpogoro FJ, Mshana SE, Mirambo MM, Kidenya BR, Gumodoka B, Imirzalioglu C. Incidence and predictors of surgical site infections following caesarean sections at Bugando Medical Centre, Mwanza, Tanzania. Antimicrob Resist Infect Control. 2014;3:25. Available from: https://doi.org/10.1186/2047-2994-3-25
12. Sahay N, Jhakhar R. Study of post caesarean section wound infection and microbiological epidemiology in tertiary care centre, western Rajasthan, India. Int J Reprod Contracept Obstet Gynecol. 2020 Apr 28;9(5):2042–6. Available from: https://doi.org/10.18203/2320-1770.ijrcog20201802
13. Cabral BG, Brasiliense DM, Furlaneto IP, Rodrigues YC, Lima KVB. Surgical site infection following caesarean section by Acinetobacter species: a report from a hyperendemic setting in the Brazilian Amazon region. Microorganisms. 2021 Apr;9(4):743. Available from: https://doi.org/10.3390/microorganisms9040743
14. Dessie W, Mulugeta G, Fentaw S, Mihret A, Hassen M, Abebe E. Pattern of bacterial pathogens and their susceptibility isolated from surgical site infections at selected referral hospitals, Addis Ababa, Ethiopia. Int J Microbiol. 2016;2016:2418902. Available from: https://doi.org/10.1155/2016/2418902
15. Sway A, Nthumba P, Solomkin J, Tarchini G, Gibbs R, Ren Y, et al. Burden of surgical site infection following cesarean section in sub-Saharan Africa: a narrative review. Int J Womens Health. 2019;11:309–18. Available from: https://doi.org/10.2147/ IJWH.S182362
16. Bessa LJ, Fazii P, Di Giulio M, Cellini L. Bacterial isolates from infected wounds and their antibiotic susceptibility pattern: some remarks about wound infection. Int Wound J. 2015 Feb;12(1):47–52. Available from: https://doi.org/10.1111/iwj.12049
17. Tenover FC. Mechanisms of antimicrobial resistance in bacteria. Am J Infect Control. 2006 Jun;34(5 Suppl 1):S3–10. Available from: https://doi.org/10.1016/j.ajic.2006.05.219
18. Jorgensen JH, Ferraro MJ. Antimicrobial susceptibility testing: a review of general principles and contemporary practices. Clin Infect Dis. 2009 Dec 1;49(11):1749–55. Available from: https://doi.org/10.1086/647952
19. Negi V, Pal S, Juyal D, Sharma MK, Sharma N. Bacteriological profile of surgical site infections and their antibiogram: a study from resource constrained rural setting of Uttarakhand state, India. J Clin Diagn Res. 2015 Oct;9(10):DC17–20. Available from: https://doi.org/10.7860/JCDR/2015/15342.6698
20. Walia K, Madhumathi J, Veeraraghavan B, Chakrabarti A, Kapil A, Ray P, et al. Establishing antimicrobial resistance surveillance and research network in India: journey so far. Indian J Med Res. 2019 Feb;149(2):164–79. Available from: https://doi.org/10.4103/ijmr.IJMR_226_18
21. Anguzu JR, Olila D. Drug sensitivity patterns of bacterial isolates from septic post-operative wounds in a regional referral hospital in Uganda. Afr Health Sci. 2007 Sep;7(3):148–54. Available from: https://doi.org/10.5555/afhs.2007.7.3.148
22. Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR. Guideline for prevention of surgical site infection, 1999. Centers for Disease Control and Prevention (CDC) Hospital Infection Control Practices Advisory Committee. Am J Infect Control. 1999 Apr;27(2):97–132.
23. Zabaglo M, Leslie SW, Sharman T. Postoperative wound infections. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2026 [cited 2026 Jun 9]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK560533/
24. Garner JS. CDC guideline for prevention of surgical wound infections, 1985. Infect Control. 1986 Mar;7(3):193–200. Available from: https://doi.org/10.1017/ s0195941700064080
25. Onyekwelu I, Yakkanti R, Protzer L, Pinkston CM, Tucker C, Seligson D. Surgical wound classification and surgical site infections in the orthopaedic patient. J Am Acad Orthop Surg Glob Res Rev. 2017 Jun 13;1(3):e022. Available from: https://doi.org/10.5435/JAAOSGlobal-D-17-00022
26. Culver DH, Horan TC, Gaynes RP, Martone WJ, Jarvis WR, Emori TG, et al. Surgical wound infection rates by wound class, operative procedure, and patient risk index. National Nosocomial Infections Surveillance System. Am J Med. 1991 Sep 16;91(3B):152S–157S. Available from: https://doi.org/10.1016/0002-9343(91)90361-z
27. Azoury SC, Farrow NE, Hu QL, Soares KC, Hicks CW, Azar F, et al. Postoperative abdominal wound infection – epidemiology, risk factors, identification, and management. Chronic Wound Care Manag Res. 2015 Sep 22;2:137–48. Available from: https://doi.org/10.2147/CWCMR.S62514
28. Kirkland KB, Briggs JP, Trivette SL, Wilkinson WE, Sexton DJ. The impact of surgical-site infections in the 1990s: attributable mortality, excess length of hospitalization, and extra costs. Infect Control Hosp Epidemiol. 1999 Nov;20(11):725–30. Available from: https://doi.org/10.1086/501572
29. Wloch C, Wilson J, Lamagni T, Harrington P, Charlett A, Sheridan E. Risk factors for surgical site infection following caesarean section in England: results from a multicentre cohort study. BJOG. 2012 Oct;119(11):1324–33. Available from: https://doi.org/10.1111/j.1471-0528.2012.03452.x
30. Gould IM. Alexander Gordon, puerperal sepsis, and modern theories of infection control—Semmelweis in perspective. Lancet Infect Dis. 2010 Apr;10(4):275–8. Available from: https://doi.org/10.1016/S1473-3099(09)70304-4