

NOSOCOMIAL INFECTIONS AND ASSOCIATED RISK FACTORS IN A NEUROSURGICAL INTENSIVE CARE UNIT: A HOSPITAL-BASED ANALYTICAL LONGITUDINAL STUDY

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Received : 27/08/2026

Received in revised form : 20/09/2026

Accepted : 03/10/2026

Keywords:

Nosocomial infection; healthcare-associated infection; neurosurgical intensive care unit; ventilator-associated pneumonia; bloodstream infection; Acinetobacter; risk factors; mechanical ventilation.

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DOI: 10.47009/jamp.2026.8.5.145

Source of Support: Nil,

Conflict of Interest: None declared

Int J Acad Med Pharm

2026; 8 (5); 914-919



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ABSTRACT

Background: Nosocomial infections are an important complication of intensive care, particularly in neurosurgical patients who frequently require prolonged hospitalization, impaired-consciousness care, mechanical ventilation, and invasive devices. **Materials and Methods:** A hospital-based analytical longitudinal study was conducted for 22 months (1 December 2018 to 30 September 2020) in the neurosurgery intensive care unit of Government General Hospital, Kakinada. Of 224 ICU admissions, 156 patients who stayed for more than 48 hours and met the study criteria were included. Clinical variables, Glasgow Coma Scale (GCS), invasive devices, antimicrobial exposure, and microbiological findings were recorded. Specimens were cultured using standard microbiological methods; isolates were identified by conventional methods and antimicrobial susceptibility was assessed by Kirby–Bauer disc diffusion according to the study protocol. Frequencies, percentages, and chi-square tests were used. Crude odds ratios (ORs) and 95% confidence intervals (CIs) in this manuscript were calculated from the reported 2×2 counts. **Result:** Nosocomial infection was documented in 88/156 eligible patients (56.4%). Using all 224 ICU admissions as the denominator, the study reported an incidence of 39.2 per 100 admissions. Mean age was 37.03±11.22 years and 64.7% were male. Mean hospital stay was longer among infected than uninfected patients (33.48±7.32 vs 15.47±3.65 days), while mean GCS was lower (8.09±1.43 vs 11.66±1.88). The commonest infection was ventilator-associated pneumonia (30.7%), followed by urinary tract infection (27.3%) and bloodstream infection (20.5%). Acinetobacter spp. (31.8%), Pseudomonas aeruginosa (27.3%), Escherichia coli (22.7%), and Klebsiella spp. (20.5%) were the most frequently reported organisms. Significant associations were observed with blood transfusion, central intravenous access, prior broad-spectrum antibiotic use, mechanical ventilation, external ventricular/lumbar drainage, tracheostomy, and reoperation. **Conclusion:** A high burden of nosocomial infection was observed in this neurosurgical ICU cohort, with ventilator-associated pneumonia and urinary tract infection predominating and Gram-negative organisms accounting for most reported isolates. Device exposure, prior broad-spectrum antibiotic use, and reoperation were among the variables associated with infection. Prospective device-specific surveillance and strengthened infection-prevention practices are warranted.

INTRODUCTION

Nosocomial or healthcare-associated infections are important complications of intensive care because

critically ill patients are exposed to invasive devices, broad-spectrum antimicrobials, prolonged hospitalization, and impaired host defenses. Large ICU surveillance studies have demonstrated

substantial burdens of ICU-acquired infection, with pneumonia, urinary tract infection, and bloodstream infection among the major syndromes and with device exposure and longer ICU stay consistently associated with infection.^[1,2]

Neurosurgical ICUs have additional vulnerabilities. Altered consciousness, disruption of protective reflexes, neurosurgical procedures, mechanical ventilation, intravascular access, urinary catheterization, ventricular or lumbar drainage, and repeated operations may increase opportunities for infection. Previous neurosurgical ICU studies have identified prolonged stay, low GCS, mechanical ventilation, broad-spectrum antibiotic exposure, and reoperation among important risk factors.^[3-7]

Local surveillance data are essential because the distribution of pathogens and infection syndromes varies between ICUs and over time. The present study evaluated the occurrence of nosocomial infection in a neurosurgical ICU, described the clinical and microbiological profile of infected patients, and examined selected demographic, clinical, therapeutic, and device-related factors associated with infection.

Objectives:

1. To determine the occurrence of nosocomial infections in the neurosurgery ICU during the study period.
2. To identify demographic, clinical, therapeutic, and device-related factors associated with nosocomial infection.
3. To describe the microorganisms isolated from infected patients and the distribution of infection syndromes.
4. To document the empirical antimicrobial and infection-prevention approaches described in the study.

MATERIALS AND METHODS

Study design and setting: This was a hospital-based analytical longitudinal study conducted over 22 months, from 1 December 2018 to 30 September 2020, in the Department of Microbiology in collaboration with the Department of Neurosurgery ICU, Government General Hospital, Kakinada, Andhra Pradesh, India.

Participants: During the study period, 224 patients were admitted to the neurosurgery ICU. Of these, 156 patients had a hospital stay exceeding 48 hours and fulfilled the study inclusion criteria. Patients of all ages and both sexes who consented to participate were included. Patients transferred from another ICU or from another clinic/ward, and repeat isolates from the same site, were excluded.

Clinical and laboratory data: Data were collected using a predesigned, pretested, semi-structured proforma. Variables included demographic characteristics, previous medical and surgical history, comorbidities, duration of hospitalization, GCS, invasive devices, procedures, antimicrobial

exposure, and selected emergency medications. Laboratory investigations included blood, urine, sputum, pus, cerebrospinal fluid when indicated, endotracheal-tube tip, and intravascular catheter-tip cultures, together with routine clinical investigations. Specimens were collected aseptically and processed immediately. Bacterial isolation was performed using standard microbiological methods with media including blood agar, MacConkey agar, chocolate agar, and brain-heart infusion broth. Organisms were identified by conventional biochemical methods, and antimicrobial susceptibility testing was performed by the Kirby–Bauer disc diffusion method according to Clinical and Laboratory Standards Institute specifications as described in the dissertation. Deep tracheal aspirates and urine samples were obtained on admission and repeated weekly; other specimens were collected when clinically indicated. Only the initial isolate from a given site was considered.

Outcome definition: The study used the concept of a nosocomial infection as an infection not present or incubating at admission and typically manifesting after 48 hours of hospitalization. The dissertation classified infections into bloodstream infection, ventilator-associated pneumonia, urinary tract infection, surgical site infection, nosocomial meningitis, respiratory tract infection, soft tissue/skin infection, and sepsis.

Statistical analysis: Data were entered in Microsoft Excel 2016 and analysed using SPSS version 23. The dissertation primarily reported frequencies, percentages, means and standard deviations, with chi-square tests for categorical comparisons. For the present manuscript, crude ORs and 95% CIs were additionally calculated from the 2×2 counts reported in the dissertation's risk-factor table. No adjusted multivariable model was performed because a reproducible adjusted regression output was not provided in the source document. A two-sided $p < 0.05$ was considered statistically significant.

Ethics: Prior approval was obtained from the Institutional Ethical Committee of Rangaraya Medical College, Kakinada (IEC/RMC/2018/366). Written informed consent was obtained from patients or their family members after explanation in the vernacular language, as documented in the dissertation. An ethics approval number was not provided in the source document.

Reporting framework: The manuscript has been structured in accordance with the general IMRAD approach recommended by the International Committee of Medical Journal Editors and with the reporting principles of the STROBE statement for observational studies.^[8,9]

RESULTS

Participant characteristics: The mean age of the 156 included patients was 37.03 ± 11.22 years. The largest age group was 31–40 years (53/156, 34.0%), followed by 21–30 years (39/156, 25.0%). Males comprised 101/156 (64.7%) and females 55/156

(35.3%). Nosocomial infection was documented in 88/156 patients (56.4%).

Table 1: Baseline demographic characteristics and infection status of the 156 eligible patients.

Characteristic	Total n (%)
Age, mean $\pm$ SD (years)	37.03 $\pm$ 11.22
<20 years	11 (7.1)
21–30 years	39 (25.0)
31–40 years	53 (34.0)
41–50 years	31 (19.0)
51–60 years	18 (11.5)
>60 years	4 (2.6)
Male	101 (64.7)
Female	55 (35.3)
Nosocomial infection present	88 (56.4)
No nosocomial infection	68 (43.6)

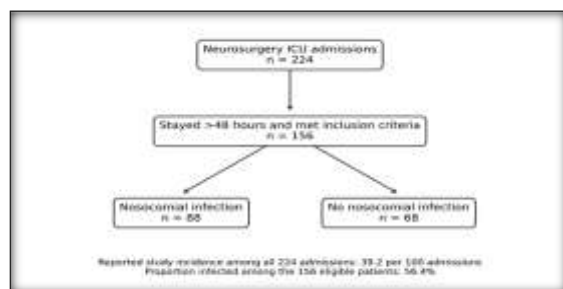


Figure 1: Study participant flow. Of 224 neurosurgery ICU admissions, 156 patients stayed >48 hours and were included; 88 developed/fulfilled criteria for nosocomial infection and 68 did not. The study reports 39.2 infections per 100 admissions and 56.4% infected among the eligible cohort.

Clinical characteristics: Among infected patients, the mean hospital stay was 33.48 $\pm$ 7.32 days

compared with 15.47 $\pm$ 3.65 days among uninfected patients. Mean GCS was 8.09 $\pm$ 1.43 in infected patients and 11.66 $\pm$ 1.88 in uninfected patients. Among infected patients, hypertension was reported in 39 (44.3%), other comorbidities in 30 (34.1%), and diabetes in 27 (30.7%).

Risk factors associated with nosocomial infection:

The reported categorical comparisons showed statistically significant associations for blood transfusion ($p=0.039$), central intravenous access ($p=0.001$), prior broad-spectrum antibiotic use ($p<0.001$), mechanical ventilation ($p<0.001$), external ventricular/lumbar drainage ($p=0.002$), tracheostomy ($p=0.008$), and reoperation ($p<0.001$). Nasogastric feeding, urinary catheterization, total parenteral nutrition, and the selected emergency medications were not statistically significant in the reported categorical analyses.

Table 2: Reported exposure frequencies and crude odds ratios for nosocomial infection. ORs and 95% CIs were calculated from the dissertation's 2 $\times$ 2 counts; p values shown are Pearson chi-square results calculated from those counts.

Exposure	Infected n/N	Uninfected n/N	Crude OR (95% CI)	p value
Nasogastric feeding	58/88	40/68	1.35 (0.70–2.60)	0.364
Urinary catheter	57/88	41/68	1.21 (0.63–2.33)	0.566
Total parenteral nutrition	43/88	31/68	1.14 (0.60–2.15)	0.685
Blood transfusion	47/88	25/68	1.97 (1.03–3.77)	0.0387
Central IV access	69/88	36/68	3.23 (1.61–6.48)	0.000772
Prior broad-spectrum antibiotics	68/88	17/68	10.20 (4.86–21.41)	7.97e-11
Mechanical ventilation	77/88	14/68	27.00 (11.39–63.99)	4.25e-17
External ventricular/lumbar drainage	43/88	17/68	2.87 (1.44–5.71)	0.00238
Tracheostomy	24/88	7/68	3.27 (1.31–8.14)	0.00841
Reoperation	65/88	24/68	5.18 (2.60–10.31)	1.39e-06

Types of nosocomial infection: Ventilator-associated pneumonia was the most frequent infection syndrome (27/88, 30.7%), followed by urinary tract infection (24/88, 27.3%) and bloodstream infection (18/88, 20.5%). Surgical site

infection accounted for 11/88 (12.5%). The remaining categories were respiratory tract infection (3.4%), nosocomial meningitis (2.3%), soft tissue/skin infection (2.3%), and sepsis (1.1%).

Table 3: Distribution of nosocomial infection syndromes among the 88 infected patients.

Infection type	n	% of infected patients
Ventilator-associated pneumonia	27	30.7
Urinary tract infection	24	27.3
Bloodstream infection	18	20.5
Surgical site infection	11	12.5
Respiratory tract infection	3	3.4
Nosocomial meningitis	2	2.3
Soft tissue/skin infection	2	2.3
Sepsis	1	1.1

Microbiological profile: Acinetobacter spp. was the most frequently reported organism (28 isolates/patients, 31.8%), followed by Pseudomonas aeruginosa (23, 27.3%), Escherichia coli (20, 22.7%), Klebsiella spp. (18, 20.5%), and Staphylococcus

aureus (16, 18.2%). Other reported organisms were Proteus spp., coagulase-negative staphylococci, Candida spp., Enterobacter spp., Enterococcus spp., Streptococcus pyogenes, and Streptococcus pneumoniae.

Table 4: Microorganisms reported among infected patients. Percentages are based on 88 infected patients and are not mutually exclusive; the reported organism counts sum to more than 88, indicating that multiple organisms/isolates may have been recorded in some patients.

Microorganism	n	% of 88 infected patients
Acinetobacter spp.	28	31.8
Pseudomonas aeruginosa	23	27.3
Escherichia coli	20	22.7
Klebsiella spp.	18	20.5
Staphylococcus aureus	16	18.2
Proteus spp.	13	14.8
Coagulase-negative staphylococci	12	13.6
Candida spp.	9	10.1
Enterobacter spp.	8	9.1
Enterococcus spp.	6	6.8
Streptococcus pyogenes	4	4.5
Streptococcus pneumoniae	1	1.1

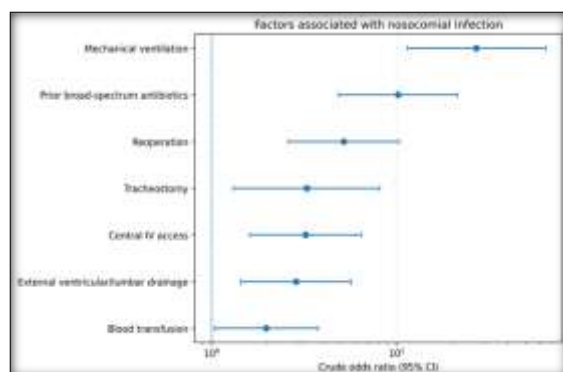


Figure 2: Crude odds ratios (95% CIs) for variables significantly associated with nosocomial infection in the reported 2×2 data. The vertical reference line denotes OR=1.

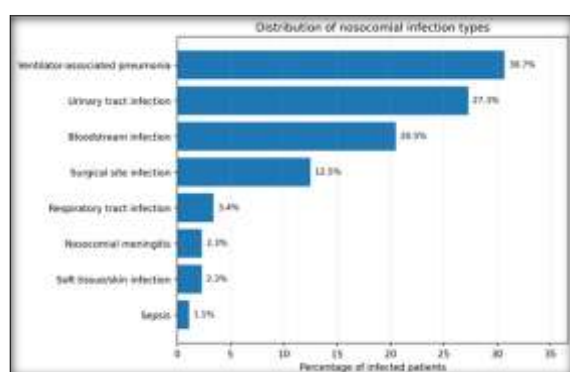


Figure 3: Distribution of nosocomial infection syndromes among infected patients.

Empirical antimicrobial therapy and infection prevention: The dissertation described syndrome-directed empirical therapy covering likely Gram-negative and Gram-positive pathogens according to the clinical syndrome. Regimens included beta-lactam/beta-lactamase inhibitor combinations, third- or fourth-generation cephalosporins, carbapenems, aminoglycosides, fluoroquinolones, glycopeptides, linezolid, metronidazole, and selected antifungals.

For suspected nosocomial meningitis, the dissertation described vancomycin plus cefepime, ceftazidime, or meropenem, with escalation options for highly resistant organisms. These historical treatment descriptions should not be interpreted as current prescribing recommendations and should be updated to the target journal's contemporary antimicrobial stewardship guidance before publication.

The documented infection-prevention measures included isolation when indicated, source/protective isolation, hand hygiene, appropriate use of gloves and gowns, masks and face/eye protection, and environmental/device precautions. The study emphasized hand hygiene as a core measure and recommended attention to catheter and invasive-device care. Evidence-based catheter and hand-hygiene guidelines remain central to prevention programs.^[10,11]

DISCUSSION

In this neurosurgical ICU cohort, 88 of 156 eligible patients (56.4%) had a nosocomial infection. The dissertation additionally reported an incidence of 39.2 per 100 ICU admissions when the 88 infected patients were related to all 224 admissions during the study period. Because only patients staying >48 hours were eligible for infection surveillance, these two denominators should not be conflated. The 56.4% figure describes the included cohort, whereas 39.2 per 100 is the study's reported admission-based incidence calculation.

The observed infection burden was greater than that reported in several earlier ICU and neurosurgical ICU studies cited in the dissertation, although direct comparison is limited by differences in study populations, infection definitions, surveillance intensity, inclusion criteria, and denominators. In a prospective ICU cohort, Ak et al. reported a 25.6% infection rate and identified length of ICU stay,

central venous catheterization, mechanical ventilation, and tracheostomy as significant risk factors.^[3] Göçmez et al. reported a lower overall incidence in a much larger neurosurgical ICU cohort and identified low GCS, prolonged stay, prior broad-spectrum antibiotics, mechanical ventilation, total parenteral nutrition, and reoperation among risk factors.^[4] The present study's pattern is directionally consistent with the importance of device exposure and impaired neurological status.

Ventilator-associated pneumonia was the leading infection syndrome in the present study, followed by urinary tract infection and bloodstream infection. This pattern is compatible with the established vulnerability of ICU patients to device-associated infections. The EPIC study reported pneumonia as the most frequent ICU-acquired infection, followed by other respiratory infections, urinary tract infection, and bloodstream infection.^[1] In the Argentine ICU surveillance study by Rosenthal et al., catheter-related bloodstream infection, VAP, and catheter-associated UTI were major infection categories.^[12]

The microbiological profile was dominated by Gram-negative organisms, with *Acinetobacter* spp., *Pseudomonas aeruginosa*, *Escherichia coli*, and *Klebsiella* spp. most frequently reported. Similar Gram-negative predominance has been described in ICU and neurosurgical ICU surveillance, although the relative proportions vary substantially by institution. Ak et al. reported *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *E. coli*, and *Acinetobacter baumannii* as leading isolates in their ICU cohort.^[3] Such variation reinforces the value of local microbiological surveillance and unit-specific antibiograms rather than reliance on external pathogen distributions.

Several device- and treatment-related variables were statistically associated with infection. Mechanical ventilation showed the largest crude association (OR 27.00, 95% CI 11.39–63.99), followed by prior broad-spectrum antibiotic exposure (OR 10.20, 95% CI 4.86–21.41) and reoperation (OR 5.18, 95% CI 2.60–10.31). These estimates are unadjusted and should not be interpreted as causal effects. Confounding by severity of illness is particularly plausible in neurosurgical ICU populations: patients requiring ventilation, reoperation, central access, or broad-spectrum antibiotics are also likely to have more severe underlying disease. The lower GCS observed among infected patients is consistent with this interpretation and with previous work linking impaired consciousness and high therapeutic intensity to ICU infection risk.^[5]

The association with prior broad-spectrum antibiotic exposure is also clinically plausible in the context of antimicrobial selection pressure, but the observational design cannot determine whether antibiotics caused infection, were prescribed because infection was already suspected, or simply marked greater illness severity. Similarly, the association of central intravenous access, ventricular/lumbar

drainage, tracheostomy, and reoperation with infection should be interpreted as epidemiologic association rather than proof of direct causation.

This study has practical implications for neurosurgical ICU surveillance. Device-associated prevention bundles, daily review of device necessity, strict aseptic technique, hand hygiene, antimicrobial stewardship, early recognition of VAP/UTI/BSI, and unit-specific microbiological surveillance are reasonable priorities. Current catheter-prevention guidance emphasizes education and training, maximal sterile barrier precautions, appropriate skin antisepsis, and ongoing surveillance.^[10] Hand-hygiene guidelines likewise emphasize hand hygiene as a core intervention to reduce transmission.^[11]

Strengths and limitations:

- The study prospectively collected clinical and microbiological information over 22 months in a dedicated neurosurgical ICU.
- It evaluated a broad set of patient, treatment, procedure, and device-related variables.
- Microbiological confirmation was based on standard culture and susceptibility-testing methods, with repeat isolates from the same site excluded.
- The study was conducted in a real-world tertiary-care setting and therefore provides useful unit-specific surveillance information.
- The sample was modest (156 eligible patients), limiting precision.
- No patient-day or device-day denominators were reported, so device-associated incidence densities could not be calculated.
- The source did not provide an adjusted multivariable regression model; therefore, the ORs presented here are crude and susceptible to confounding.
- The source tables contain some internal inconsistencies in the reported regression/OR table, so the manuscript uses transparent 2×2 calculations from the reported counts.
- The microbiological percentages sum to more than 100%, indicating non-mutually-exclusive organism reporting; the original culture records should be checked to determine whether this represents polymicrobial infection or multiple isolates.
- The study predates current infection-surveillance definitions and antimicrobial-resistance frameworks; contemporary definitions should be cross-checked at journal submission.

CONCLUSION

Nosocomial infections represented a substantial burden in this neurosurgical ICU cohort. Ventilator-associated pneumonia, urinary tract infection, and bloodstream infection were the principal infection syndromes, while *Acinetobacter* spp., *Pseudomonas aeruginosa*, *Escherichia coli*, and *Klebsiella* spp. were the most frequently reported organisms. Blood

transfusion, central intravenous access, prior broad-spectrum antibiotic use, mechanical ventilation, external ventricular/lumbar drainage, tracheostomy, and reoperation were statistically associated with infection in unadjusted analyses. The findings support continued prospective surveillance, rigorous device-care practices, antimicrobial stewardship, and reinforcement of infection-prevention measures in neurosurgical ICUs.

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