Effectiveness of minocycline/rifampin-impregnated central venous catheters in the prevention of central venous catheter-associated bloodstream infections in the neuro-intensive care unit

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Summary

Background: Central venous catheters (CVCs) are widely used in neuro-intensive care unit (Neuro-ICU), but carry a high risk of central venous catheter-associated bloodstream infections (CLABSI). Minocycline/rifampicin-impregnated CVCs (M/R-CVCs) can reduce this risk, but limited data are available specifically for Neuro-ICU. *Objective:* To evaluate the incidence and microbiological profiles of CLABSI in Neuro-ICU patients with M/R-CVCs. *Subject and method:* A prospective study was conducted among critically ill adults with M/R-CVCs. Catheter segments and blood were cultured after removal. CLABSI was defined according to CDC/NHSN 2024 criteria. *Result:* Seventy adult patients were included in the study. The mean age of patients was 57.1 years (57.07 ± 17.37), and 46 (65.7%) were male. Most patients had ≥2 comorbidities (60/70, 85.7%), and catheters remained in place for >7 days (55/70, 78.6%). Catheter colonization occurred in 11 (15.7%) cases, mainly at the insertion site. The observation period was characterized by an absence of CLABSI. The colonizing organisms were primarily Gram-negative bacilli, while catheter and blood culture results remained uncorrelated. *Conclusion:* The use of M/R-CVC was associated with a low colonization rate and the absence of CLABSI, which supports its consideration for infection prevention in high-risk patients in the Neuro-ICU.

Keywords: CLABSI; minocycline-rifampin; impregnated catheter; Neuro-intensive care unit; infection prevention.

I. BACKGROUND

Central venous catheters (CVCs) are commonly utilized in intensive care medicine. However, they significantly contribute to central venous catheter-associated bloodstream infections (CLABSI)[1], resulting in increased mortality and elevated healthcare costs[2,3]. The primary pathogenic mechanism involves the development of microbial biofilms at the skin or catheter connection site[4].

Minocycline/rifampicin-impregnated CVCs (M/R-CVCs) have demonstrated strong efficacy in reducing CLABSI risk in clinical trials, with an odds ratio of 0.29 (95% CI: 0.16 - 0.53)[5]. However, findings in high-risk settings such as Neuro-intensive care unit (Neuro-ICU) remain limited.

This study aimed to evaluate the use of M/R-CVCs in the Neuro-ICU of the 108 Military Central

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Hospital (108 MCH) to generate local evidence regarding their effectiveness in infection prevention.

II. SUBJECT AND METHOD

Study Design and Setting

A prospective study was conducted from January to December 2024 at the Neuro-ICU of 108 MCH, Vietnam. The study included 70 consecutive adult patients requiring a M/R-CVC (Arrow®) with an anticipated dwell time of ≥48 hours. Patients with pre-existing bloodstream infection or catheters inserted elsewhere were excluded.

Definitions and Microbiological Analysis

CLABSI and local catheter-related infections were defined per IDSA 2009 and CDC/NHSN 2024 criteria[6,7]. Upon removal, samples were collected from the catheter insertion site, external surface, and internal lumen; concurrent peripheral blood cultures were drawn. Microbiological processing used standard culture methods and the VITEK-2® system for identification. Antimicrobial susceptibility was determined per CLSI 2023 guidelines.

Statistical Analysis

Categorical data are presented as n (%), and continuous data as mean ± standard deviation. Statistical comparisons used Chi-square or Fisher's exact tests, with $p<0.05$ considered significant. Analyses were performed using SPSS v20.2.

III. RESULTS

The cohort consisted mainly of middle-aged men, with central nervous system trauma being the most common reason for admission. Most patients had multiple comorbidities-often hypertension and diabetes-with severe neurological status and longer hospital stays (Table 1).

Table 1. Baseline Characteristics of Patients

Characteristic	n (%)	Mean ± SD [Range]
Gender		
Male	46 (65.7)	
Age		57.07 ± 17.37 [13 - 92]
Reason for admission		
CNS trauma	42 (60)	
Main comorbidities		
Hypertension	24 (34.3)	
Diabetes mellitus	8 (11.4)	
Number of comorbidities		
≥ 2	60 (85.7)	
Clinical status on admission		
GCS		8.36 ± 2.09 [4 - 15]
Length of hospital stay, days		18.21 ± 9.05 [4 - 42]
> 14 days	44 (62.9)	

** SD, Standard deviation; GCS, Glasgow Coma Scale*

Catheterization was mainly performed via the subclavian vein or internal jugular vein, usually required only a few punctures, and remained in place for more than 7 days. Suspected infection was often accompanied by fever and leukocytosis, with significantly elevated procalcitonin and CRP levels (Table 2).

Table 2. Catheter and Clinical Characteristics at Suspected Infection

Characteristic	n (%) Mean ± SD [Range]
Catheter site	
Subclavian vein	38 (54.3)
Internal jugular vein	32 (45.7)
Number of punctures	
< 3 attempts	58 (82.9)
Catheter duration	
> 7 days	55 (78.6)
Clinical Characteristics	
Fever 37 - 38.5°C	49 (70)
Paraclinical Parameters	
WBC > 10G/L	29 (41.4)
Procalcitonin (mg/L)	2.74 ± 13.54
C-reactive protein (ng/mL)	136 ± 111.2

** WBC, white blood cell; SD, standard deviation.*

Catheter colonization occurred in 11 patients, most frequently at the insertion site, followed by external and internal segments. Importantly, no definite or probable CLABSI was identified during the study period. Four bloodstream infections were documented but attributed to non-catheter sources (Table 3).

Table 3. Characteristics of Catheter and Bloodstream Infections

Characteristic	n (%)
Catheter-Related Infections	
External catheter segment	4 (5.7)
Insertion site	8 (11.4)
Internal catheter segment	3 (4.3)
Bloodstream Infections (BSI)	
BSI due to catheter	0 (0)
BSI possibly related to catheter	0 (0)
BSI not related to catheter	4 (5.7)

Table 4. Distribution of Microorganisms and Bloodstream Infections

Microorganism	External Port (n)	Insertion Site (n)	Internal Lumen (n)	Blood (n)
A. Baumannii	1	1		
A. Nosocomialis	1	1		
P. Aeruginosa	1	1		
K. Pneumoniae	1	1		
En. Faecium		1		
En. Faecalis			2	

Microorganism	External Port (n)	Insertion Site (n)	Internal Lumen (n)	Blood (n)
E. Coli				1
C. Tropicalis	1	1		
S. Warneri	1	1		
S. Lugdunensis			1	

** A., Acinetobacter; P., Pseudomonas; K., Klebsiella; E., Escherichia; En., Enterococcus; C., Candida; S., Staphylococcus.*

Microbiological analysis revealed a diverse pathogen profile. Gram-negative bacteria predominated, mainly *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, and *Escherichia coli*. Gram-positive isolates included *Enterococcus spp*. and *Staphylococcus warneri*, while *Candida tropicalis* was the most important fungal isolate. No correlation was found between catheter and blood cultures (Table 4).

IV. DISCUSSION

This study identified demographic and clinical patterns consistent with previous CLABSI reports, in which male dominance, advanced age, and frequent comorbidities such as hypertension and diabetes were common[8-11]. Severe neurological impairment and a longer stay in the intensive care unit further increased susceptibility, which is consistent with findings from pediatric and adult cohorts[12-14].

The characteristics of vascular access were comparable to international practice. Although preference for the access site varied, pooled analyses showed no significant difference in infection risk between subclavian and jugular access[15,16,20]. The guidelines[17,19] recommend avoiding femoral access due to higher infection rates. Randomized studie[18] highlight the trade-off between subclavian access with a lower risk of infection but a higher risk of pneumothorax and jugular access with fewer mechanical complications. Prolonged dwell time and repeated punctures reflected real-world practice in intensive care units, with ultrasound guidance strongly recommended to increase insertion safety[19].

Fever and inflammatory markers were common, but no confirmed CLABSI cases were identified, highlighting the diagnostic challenges in critically ill patients. Procalcitonin may provide supportive information but lacks specificity[21].

The microbial spectrum, including enterococci, coagulase-negative staphylococci, and *Candida tropicalis*, was consistent with previous reports[22,23] from intensive care units. The detection *of Candida tropicalis* in both catheter and blood samples is clinically relevant and consistent with reports in immunocompromised hosts[24], whereas oncology cohort[25] often show different distributions.

The superiority of minocycline/rifampicin-impregnated catheters over chlorhexidine/silver sulfadiazine-impregnated catheters has been demonstrated, particularly with prolonged use[26], and complementary measures such as chlorhexidine dressings support bundled prevention strategies[27].

The absence of CLABSI cases in our cohort may be influenced by several factors. First, the sample size was relatively small and the observation period was limited to a single year, which may have led to an underestimation of rare events. Second, all catheters were handled by a trained Neuro-ICU team in accordance with a strict infection control protocol, which may have minimized the risk of contamination. Finally, microbiological sampling was performed only once at catheter removal; multiple time-point cultures may have increased diagnostic sensitivity.

Limitations include the design as an observational study at a single center without a control group, the relatively small sample size, and the single sampling, which may underestimate intermittent bacteremia or colonization. Furthermore, due to the lack of molecular typing, the identity of the pathogens between catheter and blood isolates could not be confirmed. Nevertheless,

the results provide further evidence for the use of antibiotic-impregnated catheters in neurocritical care. Future multicenter studies should further evaluate their effectiveness, integration with complementary measures, and cost-effectiveness in intensive care practice.

IV. CONCLUSION

These findings suggest a potential role for Minocycline/rifampicin-impregnated central venous catheters in high-risk populations, though larger multicenter studies are required to confirm efficacy and assess cost-effectiveness.

Conflict of Interest

The authors declare no competing interests.

Authors' Contributions

CTN: Conceptualization, Methodology, Drafting. TVN, VLN, DTT, TNBG, DLN and TTT: Data Curation, Analysis. DTL and HMN: Supervision, Review & Editing. All authors approved the final manuscript and are accountable for its content.

Ethics Approval and Consent to Participate

This non-interventional study used anonymized routine clinical data and did not involve any additional procedures or risks for patients. Therefore, in accordance with the institution's guidelines and the principles of the Declaration of Helsinki, no formal ethical approval or informed consent was required.

Consent for Publication

All authors consented to publication.

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Availability of Data and Materials

Data are available from the corresponding author upon reasonable request.

Ethical Publishing Statement

This manuscript is original, not under review elsewhere, and all data are accurate and authentic.

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