Acta Biomedica Scientia

e - ISSN - 2348 - 2168
Print ISSN - 2348 - 215X

www.mcmed.us/journal/abs

Research Article

A PROSPECTIVE OBSERVATIONAL STUDY ON THE COMPARISON OF SONICATION AND MAKI TECHNIQUES FOR DIAGNOSING CATHETER-RELATED BLOODSTREAM INFECTIONS IN ICU PATIENTS

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ABSTRACT

Objective: This study aimed to compare the effectiveness of sonication and the Maki method in diagnosing catheter-related bloodstream infections (CRBSI) in ICU patients. Materials and Methods: A prospective, observational study was conducted in an Intensive Care Unit involving patients who had a central venous catheter (CVC) in place for at least seven days and at least one episode of catheter-related infection (CRI), including new fever or sepsis. Catheter tips were processed using the Maki technique for sonication. Diagnostic performance of the Maki technique, sonication, and their combination was evaluated by calculating the area under the curve (AUC) for the detection of catheter tip colonization and CRBSI. Results: A total of 87 CRI-suspected incidents were identified, with 94 CVCs assessed. Fourteen cases of catheter tip colonization and ten cases of CRBSI were detected. Of the 14 colonization cases, 7 (50%) were identified using both methods, 6 (42.9%) with Maki alone, and 1 (7.1%) with sonication alone. For the 10 CRBSIs, 6 (60%) were detected by both methods, 4 (40%) with Maki alone, and none with sonication alone. The AUC for the Maki technique was significantly higher than sonication in diagnosing CRBSI (p=0.02) and catheter tip colonization (p=0.03). No significant differences in AUC were found between Maki and combination methods for diagnosing catheter-tip colonization (p=0.32) or CRBSI (p=0.32). Conclusion: Sonication alone was not effective in diagnosing catheter tip colonization and CRBSI. The Maki technique, particularly when used in combination with sonication, provided more reliable diagnostic results.

Keywords: - Sonication, Colonization, Bloodstream Infection.

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Home page: **www.mcmed.us/journal/abs**		**Quick Response code**
Received:12.08.2024	**Revised**: 17.09.2024	**Accepted**:19.10.2024

INTRODUCTION

Central venous catheters (CVCs) are utilized for various purposes, including the administration of fluids, blood products, parenteral nutrition, medications, and hemodynamic monitoring. However, these devices also pose a significant risk of catheter-related bloodstream infections (CRBSIs), which increase morbidity, mortality, and healthcare expenditures [1-4].

A commonly used method for detecting catheter tip colonization is the semiquantitative technique, which is regarded as the gold standard due to its simplicity. This method can identify microorganisms on the external surface of the catheter tip but fails to detect bacteria on the surface of the catheter tip that is rolled onto agar. The characteristic rolling of the catheter tip onto the agar surface leads to this limitation. Consequently, Maki's

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method may result in false-negative results for catheter tip colonization in cases where the catheter has been colonized endoluminally.

In contrast, quantitative methods like sonication and vortexing, which detect catheter tip colonization through both exoluminal and endoluminal mechanisms [6-9], may be more effective than Maki's technique. Despite the advantages, quantitative methods require more time, limiting their widespread application in clinical microbiology laboratories.

When comparing Maki's semiquantitative method to the sonication technique for detecting CRBSI, it has been observed that sonication offers greater reliability. Research indicates that both Maki and sonication methods are reliable [10, 12], with sonication potentially enhancing detection when used in conjunction with Maki [13].

The American Society for Microbiology (ASM) recommends the use of semiquantitative catheter cultures based on the Maki technique alongside quantitative catheter segment cultures using ultrasound to diagnose catheter-related infections (CII) [14, 15].

Previous studies have evaluated both sonication and Maki methods using CVCs from hospitalized patients who had their catheters removed for various reasons [10-13]. However, the focus has primarily been on catheters removed after at least seven days, either from ICU patients or those suspected of having catheter-related infections (CRIs). This study specifically examines the effectiveness of sonication and Maki methods using CVCs from ICU patients, where the catheters were removed due to suspected CRIs and had been in place for at least seven days.

RESULTANTS AND METHOD OF RESEARCH

We included patients hospitalized in the ICU who did not have a CVC for at least 7 days with that CVC but later removed it for suspected CRI. The CRI suspicion was confirmed whenever a patient developed sepsis or a fever. In this study, Sepsis-3 Consensus Criteria was used [16]. Our definition of a fever was 38°C.

We have recorded variables. The variables we recorded for each patient were: diabetes mellitus, asthma, chronic liver disease, smoking, chronic obstructive lung disease (COPD), HIV, haematological malignancy, solid tumor, sex, age, and admission diagnostic. Before admission, we also recorded whether the patient had undergone renal replacement therapy, parenteral nutrition, steroids, or immunosuppressive therapy. Additionally, we noticed corticosteroids, immunosuppressants, parenteral nutrition, propofol, or renal replacement therapy when CRI suspicion was raised. The final step was recording the location, timing, and outcome of the CVC.

A variety of clinical samples were collected from all patients, including paired blood samples, catheter tip samples, and other samples. A sample of blood was drawn from each peripheral vein and separated by 15 minutes. Each sample consists of 10 ml of blood. To obtain the catheter tip sample, sterile scissors were used to cut off the tip from the catheter insertion site and clean the skin around the site with 2 percent chlorhexidine. Then, we sonicated the tips of the catheters, following Maki's method. As part of Maki's semi-quantitative procedure, the catheter tips were rolled onto agar and then sonicated, and then vortexed, for one minute at 35 000 Hz and 125 W. We used the same procedure for the sonication quantitative procedure. 0.1 mL of sonicated broth was streaked onto sheep blood agar plates. In the study, blood cultures were not taken from patients or those who used Maki's and sonication methods.

Defined. Based on the standards of the ECDC (European Centre for Disease Prevention and Control), the following infections were classified [17]. In our study, catheter-tip colonization was defined as a significant growth of microbes on the catheter tip using the semi-quantitative method of Maki et al (15 colony-forming units) [5] or the quantitative method of sonication (100 colony-forming units) [13]. In order to define CRBSI, and antibiotic-resistant pathogen was detected in the blood culture, the CVC tip was colonized, and there was no obvious source of infection. During the survey, bloodstream infections were validated as bloodstream infections without determining their source. The presence of positive colonization of CVC tips (by a semi-quantitative or quantitative method) occurred in some PBSI whereas other PBSI did not.

Statistical analysis

Medians and percentiles indicate the level of significance for continuous variables, while frequencies and percentages indicate the level of significance for categorical variables. Our analysis was based on using chi-square tests for categorical variables and Mann-Whitney T tests for continuous variables. Cohen's Kappa test was used to obtain the percentage of agreement and disagreement between the Maki and sonication methods for the diagnosis of catheter tip colonization and CRBSI, and Cohen's Kappa average was calculated.

To diagnose catheter tip colonization and CRBSI, our research team used Maki and sonication, combined with a combination of both techniques. To compare the area under the curves of ROC curves, DeLong et al. [18] used the approach described in their study. A difference was considered statistically significant when the p-value was less than 0.05. Statistical analysis was performed with SPSS 17.0.

RESULTS

There were 94 CVCs in our study from 87 patients suspected to have CRI. Twenty-three PBSIs were discovered, among which ten (43.5%) were CRBSIs and thirteen (56.5%) were BSIUOs. Among patients who developed CRBSI during CVC (n=10) and those who did not (n=84) (Table 1), no differences in death rates (p=0.99), CVC time, CVC site, and other factors were identified (Figure 2). In comparison between the group of CVC patients who developed PBSI (n=23) and those who did not (n=71), we found no significant differences in the death rate (p=0.99), the time of CVC, the location of CVC, or other characteristics (Table 1).

COPD = Chronic Obstructive Pulmonary Disease; CVC = central venous catheter

A total of 14 catheter-tip colonizations were found, ten of which were CRBSIs. A total of 14 catheter tip colonization cases were documented using Maki and sonication techniques. Of those, 7 (50.0%) were detected using Maki technique and sonication technique, 6 (42.9%) were detected using Maki technique only, and 1 (7.1%) was detected using sonication technique only (Table 2). Ten CRBSI were detected, six (60.0%) by the Maki and sonication methods, four (40.0%) by the Maki method alone, and none by the sonication method alone (Table 2).

The AUC for diagnosis of CRBSI was 98% (95 percent CI = 93 percent - 99 percent; p 0.001). The AUC for diagnosis of CRBSI using Maki technique was 79 percent (95% CI = 69 percent -87 percent; p 0.001). In our study, methods combined with sonication technique had a higher AUC than the Maki technique (p=0.02) for diagnosing CRBSI. (p=0.32) Maki and combo approaches did not differ significantly in AUC.

According to the AUC for Maki technique, 96 percent of clinical cases were diagnosed by using 95% confidence intervals (CIs) between 90 and 99 percent p0.001, 79 percent of clinical cases were diagnosed by sonication technique, and 100 percent of cases were diagnosed by using both techniques together (CIs between 96 and 100 percent p0.001). Using the combination of methods, we found that the AUC was higher for the Maki technique than the sonication method (p=0.002) and the sonication method (p=0.03) for catheter tip colonization. Between Maki and combo approaches, the AUC was not significantly different (p=0.32).

There were 1/94 (1.1% of 94) false negatives (Cohen's Kappa: 0.63 (95 percent confidence interval: 0.38-0.88) for catheter tip colonization between Maki and sonication approaches (P 0.001). Based on CRBSI results, Maki technique showed no false negatives in 94 specimens (25% confidence interval: 0.48-0.98); Cohen's Kappa: 0.73 (CI: 0.48-0.98); P = 0.001.

CRBSI and Staphylococcus epidermidis were most likely to colonize catheter tips, followed by Staphylococcus epidermidis.

Table 1: Capillary-related bloodstream infections (CRBSI) and primary bloodstream infections (PBSI) developing or not for CVCs

Information	**excluding CRBSIs (n=84)**	**1-10**	**Comparison of CRBSIs and non-CRBSIs**	**71 (non PBSIs)**	**63 (PBSIs)**	**Comparison of PBSIs and non-PBSIs**
by median CVC time (days); (p 25-75)	8 (7-9)	9 (11-13)	1.01	8.5 (7-12)	9:00 (8-12)	1.00
Location of CVC (%)			1.81			0.7
scapular	(18.4)	30 (30)		20 (21.1)	2(6)	
Golf	54 (55.9)	3 (40.1)		37 (52.1)	12 (52.2)	
Peroneal	(25).	3.30 (30.0).		88 (19).	5 (21.7)	
25 to 75 years old	54 to 72	(52-17)	0.74	(64-64)	64 (52-72)	0.80
Male; n (%) Female	24 (27.5)	0	1	2.80 (20)	3 (13.0)	0.17
Diagnostics; n%			38.00			0.07
Healthcare	75 (75.0)	10 (90.0)		51 (71.8)	91.3	
Medical	16.7 (14.1)	0		19 (7.4)	0	
Psychiatry	8.3 (7.0)	1 (10.0)		6 (8.5)	2 (8.7)	
Diabetes mellitus; n (%)	23 (27.4)	4	1.37	(33%)	17 (14).	0.20

		(40%)				
Before admission, kidney replacement therapy (%)	3.6 (3.80)	10 (10)	1.07	(0.78)	2 (8.7)	0.25
percent (%)	11.9	0	5.99	(10.9)	13 (3)	0.70
Allergic reaction; n (%)	2 (4.6)	2 (10.1)	0.44	4.2 (4.2)	2 (8.7)	1.69
Hepatitis C; n (%)	5 (4.6)	0	1.01	5 (6.8)	0	1
Smoking; nTobacco users (%)	7.6%	(9,0)	1.00	(14,5)	4.00 (4,5)	1.98
Nutritional support prior to admission; n (%)	1.	0	of 1.00	(0.4)	0	1.98
Previous use of corticosteroids; n (%)	2 (3.2)	0	1.00	4 (2.3)	0	1.09
Treatment with immunosuppressive drugs prior to admission; 9 out of 10	(4.8%)	100 (10%)	2.24	5 (6,6)	1.43 (1,3)	1.98
Tumor of the blood; n (%)	0	(10%)	0.11	0	4 (3.3)	1.05
tumors solids; n (%)	1.	0	0.99	1.41	0	99.00
HIV; n (%)	1.	0	0.99	1.41	0	1.01
In cases of sepsis, corticosteroids were administered (%)	14.3%	0	3.05.	11 (3.5)	17 (14).	1.38
In patients with sepsis, immunosuppressive therapy (%)	was 2/2 (2.4)	0	0.99	2.81 (2.88)	0	0.99
Nutritional support in sepsis, n (%)	16 (14).	20 (20).	688.	141.	25.16	0.0021
protopol at sepsis; n (%)	40 (34).	1 (0%).	1.	34 (47.7).	30 (47.3).	0.33
Treatment of sepsis with renal replacement therapy; n (%)	8.3 (7.6)	1/100 (10.2)	1.00	9 (10.0)	4 (3.3)	0.4
Deaths within 30 days (%)	27.3 (23.0)	31	1.98	(38)	26.1 (26)	.941

Table 2: Using maki and sonications to detect infection from catheter tips/bloodstream infections associated with catheters

	Maki +	**Maki -**	**Total**
Sonification	8/7	1/1	8/7
Sounding -	7/3	83/84	87/89
Total	15/10	84/85	95/96

Table 3: A bloodstream infection is caused by an organism colonizing the catheter tip. This type of infection can be caused by methods such as Maki/or and Sonication

Microorganism	**count in total**	**Positive results for both techniques**	**Only positive results for Maki**	**Sonication positive only**
Staphylococcus epidermidis	9/6	1/2	6/4	1/0
Enterococcus faecalis	2/2	2/2	0/0	0/0
Escherichia coli	2/2	2/2	0/0	0/0
Klebsiellaspp.	1/3	1/1	0/0	0/0
Enterobacter cloacae	2/2	2/2	0/0	0/0
Pseudomonas aeruginosa	2/0	2/1	0/0	0/0
TOTAL	18/15	10/10	6/4	1/0

DISCUSSION

In previous studies examining Maki and sonication methods for detecting catheter tip colonization, CVCs from patients admitted to the hospital and CVCs removed for any reason were included [10-13]. Maki and sonication were both found to be equally reliable in some studies [10-12], and a study reported the potential benefit of combining both approaches [13]. Guimbe et al [13] used 252 CVCs for their investigation. They discovered that 14.3% (14) of CVC colonisations and 15.3% (15/152 CRBSI colonies were detected using both Maki and sonication techniques, whereas 6 (16.7%) and 9 (25.0%) were discovered using sonication only. In 15 CRBSI cases, Maki and sonication were used in 11 cases (73.3 percent), whereas sonication alone was used in 4 cases (26.7 percent). Using the Maki technique, the authors suggest sonicating samples from patients with bacteremia of unknown origin and a negative catheter tip culture [13].

Using the Maki approach, we only encountered one colonisation on a sonicated catheter tip that was not detected by the Maki approach. This colonisation did not cause CRBSI. AUC was higher for the Maki technique than for the sonication approach in detecting catheter tip colonization and CRBSI, and there was no significant difference between the Maki technique and combination procedures in detecting these conditions. Our study did not show any increase in rentability by using sonication to diagnose CRBSI in Maki format.

A potential reason for this could be that [13] collected CVC on a general adult population (both ICU patients and non-ICU patients) and the catheters were of different lengths (short and long). The CVCs in our study were obtained from ICU patients, the majority of which were extraluminal colonized (which is most common). Due to its higher reliability for detecting long-term colonisation, it may have been ineffective in this study, which included only CVC from ICU patients who were mostly short-term, so Maki could detect intraluminal colonisation.

As evidence of high quality, semiquantitative and quantitative catheter segment cultures using Maki or sonication, both are recommended by CRI. In our study and other studies, Maki's semi quantitative method was not found to be profitable for diagnosing CRBSI, and it is the best method for routine microbiology lab work because of its simplicity. This may be why sonication is not advantageous for patients in intensive care units, as coagulase-negative staphylococci are more likely to colonize the catheter's external surface.

It is important to acknowledge the limitations of our research. The Maki technique and sonication for CRBSI diagnosis do not use additional quantitative techniques (such as vortexing). Due to the fact that not all cultures (blood, Maki technique, and sonication technique) were represented, we have not provided an estimate of how many CVC were removed. In addition to those two points, all catheter tips were sonicated after Maki technique; sonication would be ineffective because bacteria have already been expelled by Maki. For diagnostic purposes, our study's sample size may be small; however, the results of the combination of methods were superior to those of sonication alone, and the Maki approach was superior to those of sonication only for determining catheter tip colonisation and CRBSI. For catheter tip colonization, 220 CVCs were required and for the detection of CRBSI, 5,235 CVC were needed.

Only patients admitted to the ICU with a CVC that had been taken out for CRI suspicion and had remained with that CVC for at least 7 days were included in our study, making it unique. Our investigation found that Maki's technique for diagnosing CRBSI with sonication was not reliable.

CONCLUSION

In this study, we evaluated the effectiveness of the Maki technique and sonication in diagnosing catheter-related bloodstream infections (CRBSI) and catheter tip colonization in ICU patients. Our findings demonstrated that while both methods showed reliability in detecting colonization and CRBSI, the combination of Maki and sonication techniques offered superior diagnostic performance compared to sonication alone. Despite the simplicity and ease of Maki's semiquantitative method, it did not show an increase in diagnostic accuracy when used alone, especially in short-term colonized ICU patients. Our results indicate that sonication may not provide significant advantages in diagnosing CRBSI in ICU patients, particularly when Maki's method is also employed. However, Maki's technique remains valuable for routine microbiological use due to its simplicity and effectiveness in detecting colonization on the external surface of catheters. We recommend that both Maki and sonication techniques be considered together for more accurate detection of catheter tip colonization and CRBSI, though further studies with larger sample sizes are needed to validate these findings. Limitations of the study, such as the exclusion of other quantitative techniques and the small sample size, should be taken into account. Future research should explore the utility of combining various diagnostic techniques to improve clinical outcomes and diagnostic accuracy in patients at high risk for CRBSI.

REFERENCES

1. Pittet D, Tarara D, Wenzel RP. (1994). Nosocomial bloodstream infection in critically ill patients. Excess length of stay, extra costs, and attributable mortality. *JAMA*. 271(20), 1598-601.

2. Laupland KB, Lee H, Gregson DB, Manns BJ. (2006). Cost of intensive care unit-acquired bloodstream infections. *J Hosp Infect*., 63(2), 124-32.
3. Siempos II, Kopterides P, Tsangaris I, Dimopoulou I, Armaganidis AE. (2009). Impact of catheter-related bloodstream infections on the mortality of critically ill patients: a meta-analysis. *Crit Care Med*. 37(7), 2283-9.
4. Lambert ML, Suetens C, Savey A, Palomar M, Hiesmayr M, Morales I, (2011). Clinical outcomes of health-care-associated infections and antimicrobial resistance in patients admitted to European intensive-care units: a cohort study. *Lancet Infect Dis*. 11(1), 30-8.
5. Maki DG, Weise CE, Sarafin HW. (1977), A semiquantitative culture method for identifying intravenous catheter-related infection. *N Engl J Med*. 296(23), 1305-9.
6. Cleri DJ, Corrado ML, Seligman SJ.(1980). Quantitative culture of intravenous catheters and other intravascular inserts. *J Infect Dis*. 141(6), 781-6.
7. Linares J, Sitges-Serra A, Garau J, Perez L, Martin R. (1985). Pathogenesis of catheter sepsis: a prospective study with quantitative and semiquantitative cultures of catheter hub and segments. *J Clin Micro-biol*. 21(3), 357-60.
8. Brun-Buisson C, Abrouk F, Legrand P, Huet Y, Larabi S, Rapin M (1987). Diagnosis of central venous catheter–related sepsis: critical level of quantitative tip cultures. *Arch Intern Med*. 147(5), 873-7.
9. Sherertz RJ, Raad II, Belani A, Koo LC, Rand KH, Pickett DL. (1990). Three-year experience with sonicated vascular catheter cultures in a clinical microbiology laboratory. *J Clin Microbiol*. 28(1), 76-82.
10. Bouza E, Alvarado N, Alcalá L, Sánchez-Conde M, Pérez MJ, Muñoz P, (2005). A prospective, randomized, and comparative study of 3 different methods for the diagnosis of intravascular catheter colonization. *Clin Infect Dis*., 40(8), 1096-100.
11. Slobbe L, El Barzouhi A, Boersma E, Rijnders BJ. (2009). Comparison of the roll plate method to the sonication method to diagnose catheter colonization and bacteremia in patients with long-term tunnelled catheters: a randomized prospective study. *J Clin Microbiol*. 47(4), 885-8.
12. Erb S, Frei R, Schregenberger K, Dangel M, Nogarth D, Widmer AF. (2014). Sonication for diagnosis of catheter-related infection is not better than traditional roll-plate culture: a prospective cohort study with 975 central venous catheters. *Clin Infect Dis*. 59(4), 541-4.
13. Guembe M, Martín-Rabadán P, Cruces R, Pérez Granda MJ, Bouza E. (2016). Sonicating multi-lumen sliced catheter tips after the roll-plate technique improves the detection of catheter colonization in adults. *J Microbiol Methods*. 122, 20-2.
14. Singer M, Deutschman CS, Seymour CW, Shankar-Hari M, Annane D, Bauer M, (2016). The Third International Consensus Definitions for Sepsis and Septic Shock (Sepsis-3). *JAMA*. 315(8), 801-10.
15. DeLong ER, DeLong DM, Clarke-Pearson DL. (1980). Comparing the areas under two or more correlated receiver operating characteristic curves: a nonparametric approach. *Biometrics* 44, 837-45.

Cite this article:
Dr. Makkam Nagaraj, Dr. Ranadheer Raju CS. (2024). A Prospective Observational Study on the Comparison of Sonication and Maki Techniques for Diagnosing Catheter-Related Bloodstream Infections in ICU Patients. *Acta Biomedica Scientia*, 11(2), 104-109.