



Prospective Study

Adding vortexing to the Maki technique provides no benefit for the diagnosis of catheter colonization or catheter-related bacteremia

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Abstract

BACKGROUND

A previous study compared vortexing and Maki techniques for the diagnosis of catheter-related bloodstream infection (CRBSI), and concluded that vortexing was not superior to Maki method.

AIM

To determine whether the combined use of vortexing and Maki techniques provides profitability versus the Maki technique for the diagnosis of catheter tip colonization (CTC) and CRBSI.

METHODS

Observational and prospective study carried out in an Intensive Care Unit. Patients with suspected catheter-related infection (CRI) and with one central venous catheter for at least 7 days were included. The area under the curve (AUC) of the Maki technique, the vortexing technique and the combination of both techniques for the diagnosis of CTC and CRBSI were compared.

RESULTS

We included 136 episodes of suspected CRI. We found 21 cases of CTC of which 10 were also CRBSI cases. Of the 21 CTC episodes, 18 (85.7%) were diagnosed by Maki technique and vortexing technique, 3 (14.3%) only by the technique of Maki, and none only by technique of vortexing. Of the 10 CRBSI episodes, 9 (90.0%) were diagnosed by the techniques of Maki and vortexing, 1 (10.0%) was diagnosed only by the technique of Maki, and none only by the technique of

vortexing. We no found differences in the comparison of AUC between the technique of Maki and the combination of Maki and vortexing techniques for the diagnosis of CTC ($P = 0.99$) and CRBSI ($P = 0.99$).

CONCLUSION

The novel finding of our study was that the combined use of vortexing and Maki techniques did not provide profitability to the technique of Maki alone to CRBSI diagnosis of.

Key Words: Vortexing; Maki; Bloodstream infection; Colonization

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Core Tip: A previous study compared vortexing and Maki techniques for the diagnosis of catheter-related bloodstream infection (CRBSI), and concluded that vortexing was not superior to Maki the method. The novel finding of our study was that the combined use of vortexing and Maki techniques did not provide profitability to the technique of Maki alone to the diagnosis of CRBSI.

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INTRODUCTION

Different motives are responsible for the need of a central venous catheter (CVC), such as the monitorization of hemodynamic status or the administration of medications, fluids, parenteral nutrition or blood products. However, different risks are attributed to the use of CVC, for example, catheter-related bloodstream infection (CRBSI) that involves increased mortality, assistant costs and morbidity[1-3].

The semiquantitative Maki technique, due to its simplicity, is considered the standard technique for the diagnosis of catheter tip colonization (CTC)[4]. However, as it consists of rolling the catheter tip across the agar (detecting the microorganism from the outer surface of the catheter tip), it has the potential disadvantage that it could not detect the microorganism from the inner surface. Thus, false negative of CTC could appear in the Maki technique of patients with endoluminal colonization. Quantitative techniques (such as vortexing or sonication) for CTC diagnosis could have a potential advantage over the Maki technique due to their potential ability to detect CTC by endoluminal mechanism (which is important in long term catheters) and not only by exoluminal mechanism[5-8]. However, all quantitative methods are more time consuming than the Maki technique, so its use in clinical microbiology laboratories is not widespread.

To our knowledge, there is only one study reporting data about the comparison between the vortexing quantitative technique and the Maki's semiquantitative technique for the diagnosis of CRBSI, and it concluded that vortexing was not superior to the Maki method[9].

The same strength of recommendations and quality of evidence (A-II) have been established for the Maki technique and the vortexing technique for the diagnosis of intravascular catheter-related infection (CRI) in recent guidelines[10,11].

A previous study were compared vortexing and Maki techniques in the diagnosis of CRBSI[9]; however, this study did not compare the combined use of vortexing and Maki over only the Maki technique for the diagnosis of CTC and CRBSI, and this was the novel objective of our study.

MATERIALS AND METHODS

Design and subjects

This prospective and observational study was carried with the approval of the Institutional Ethic Committee of the Hospital Universitario de Canarias (Tenerife, Spain). Patient recruitment was performed in the Intensive Care Unit of this hospital between April 2022 and September 2022 with informed consent signed by the patients or a member of their family.

Patients with suspicion of CRI and with long term CVC (at least 7 d) were included. CRI was suspected when a patient developed a new episode of fever (temperature $\geq 38^{\circ}\text{C}$) or sepsis (according to Sepsis-3 Consensus criteria of 2016[12]). We used CVC type ARROWg⁺ard Blue[®] (Arrow, Reading, PA, United States), which were impregnated on chlorhexidine-silver sulfadiazine on the external and internal surfaces).

Variables recorded

For each suspected CRI, the age and sex of the patient and the place and time of CVC were recorded. In addition, intensive care unit (ICU) admission diagnosis, personal history of diabetes mellitus, chronic obstructive pulmonary disease, asthma, smoking, chronic liver disease, hematological tumor, human immunodeficiency virus or solid tumor were recorded. In addition, we recorded the use of renal replacement, corticosteroids or immunosuppressants previously to ICU admission, and the use of corticosteroids, parenteral nutrition or propofol at the time of suspected CRI. Finally, we also registered death within 30 days of suspected CRI.

Sample collections

We collected paired catheter tip samples, blood samples and necessary clinical samples from each patient. Paired peripheral vein blood samples were collected 15 min apart with 10 mL of blood in each sample. Catheter tip samples were taken; and for this, the skin surrounding the insertion site was previously rubbed with 2% chlorhexidine and the tip was cut with sterile scissors (5 cm of distal segment). Initially, the distal segment of the catheter tip was cultured using the Maki technique and subsequently using the vortex technique. For the semiquantitative Maki technique, the distal segment of the catheter tip was plated on a blood agar plate[4]. For the quantitative vortexing technique, the distal segment of the catheter tip was placed with 1 mL of brain-heart infusion broth in a vortexing device and vortexed for 1 min. After vortexing for 1 min, 0.1 mL of that suspension was seeded on blood agar[9]. We excluded patients without culture with Maki tip technique, culture with vortex tip technique, and blood cultures.

Definitions

We use the criteria of European Centre for Disease Prevention and Control for definitions of infections[13]. We considered CTC when a significant growth on the CVC tip of a microorganism was obtained by semi-quantitative method of Maki (≥ 15 colony-forming units)[4] or by quantitative method of vortexing (≥ 1000 colony-forming units)[9]. CRBSI was defined as the presence of the same recognized pathogen in the blood culture and in the CVC tip without no other apparent source of infection. Two positive blood cultures (obtained in a separation of 48 h) for a common skin contaminant (*Micrococcus spp.*, *Coagulase-negative staphylococci*, *Propionibacterium acnes*, *Corynebacterium spp.* and *Bacillus spp.*) were required.

Statistical analysis

We reported categorical variables as frequencies (%) and continuous variables as medians (25%-75%). Categorical variables were compared using the chi-square test and continuous variables by the Mann-Whitney *T* test. The area under the curve (AUC) of the Maki technique, the vortexing technique and the combination of both techniques for the diagnosis of CTC and CRBSI were compared using the method of DeLong *et al*[14]. We carried out statistical analyses with SPSS 17.0 software (SPSS Inc., Chicago, IL, United States) and we considered *P* values lower than 0.05 as significant.

RESULTS

We included 136 episodes of suspected CRI. We found 21 cases of CTC of which 10 were also cases of CRBSI. We found that CVC that developed CRBSI ($n = 10$) showed higher CVC time ($P = 0.02$) compared to those that did not develop it ($n = 126$); however, no other significant differences between CVC who did or did not develop CRBSI were found (Table 1).

We found 21 episodes of CTC and 10 episodes of CRBSI. Of the 21 episodes of CTC, 18 (85.7%) were diagnosed by the techniques of Maki and vortexing, 3 (14.3%) were diagnosed only by the technique of Maki, and none was diagnosed only by the technique of vortexing (Table 2). Of the 10 episodes of CRBSI, 9 (90.0%) were diagnosed by the techniques of Maki and vortexing, 1 (10.0%) was diagnosed only by the technique of Maki technique, and none was detected only by the technique of vortexing (Table 3).

The AUC for CTC diagnosis was 100% (95%CI = 97%-100%; $P < 0.001$) to the technique of Maki, 93% (95%CI = 87%-97%; $P < 0.001$) to the technique of vortexing and 100% (95%CI = 97%-100%; $P < 0.001$) by the combination of techniques. No differences had in the comparison of AUC between the technique of Maki and the combination of techniques ($P = 0.99$) for CTC diagnosis.

The AUC for CRBSI diagnosis was 96% (95%CI = 91%-98%; $P < 0.001$) to with the technique of Maki, of 91% (95%CI = 85%-96%; $P < 0.001$) with the technique of vortexing and 96% (95%CI = 91%-98%; $P < 0.001$) with the combination of techniques. No differences had in the comparison of AUC between the technique of Maki and the combination of techniques ($P = 0.99$) for CRBSI diagnosis.

The microorganisms responsible for CTC were the following: *Staphylococcus epidermidis* 6 (2 with CRBSI), *Staphylococcus haemolyticus* 3 (1 with CRBSI), Methicillin-sensitive *Staphylococcus aureus* 1 (1 with CRBSI), Methicillin-resistant *Staphylococcus aureus* 1 (1 with CRBSI), *Pseudomonas aeruginosa* 2 (2 with CRBSI), *Klebsiella spp.* 3 (2 with CRBSI), *Acinetobacter spp.* 1, *Serratia* 1, *Candida albicans* 2, *Candida glabrata* 1 (1 with CRBSI).

DISCUSSION

To our knowledge, there is only one study reporting data on the comparison between the quantitative vortexing technique and the semiquantitative Maki technique for the diagnosis of CRBSI, and it concluded that vortexing was not

Table 1 Characteristics of central venous catheter with suspicion of catheter-related infection that developed or not catheter-related bloodstream infection

Data	Non CRBSI (<i>n</i> = 126)	CRBSI (<i>n</i> = 10)	<i>P</i> value (CRBSI vs non)
Time of CVC (d) [median (p 25-75)]	9 (7-12)	12 (10-18)	0.02
Site of CVC, <i>n</i> (%)			0.19
Subclavian	28 (22.2)	3 (30.0)	
Jugular	62 (49.2)	2 (50.0)	
Femoral	36 (28.6)	5 (50.0)	
Age (yr, p 25-75)	65 (57-70)	65 (58-75)	0.50
Sex female, <i>n</i> (%)	30 (23.8)	1 (10.0)	0.45
Admission diagnostic, <i>n</i> (%)			0.74
Medical	73 (57.9)	7 (70.0)	
Surgical	39 (31.0)	2 (20.0)	
Traumatology	14 (11.1)	1 (10.0)	
Diabetes mellitus, <i>n</i> (%)	39 (31.0)	3 (30.0)	0.99
COPD, <i>n</i> (%)	16 (12.7)	0	0.61
Asthma, <i>n</i> (%)	3 (2.4)	0	0.99
Chronic liver disease, <i>n</i> (%)	25 (19.8)	0	0.21
Smoking, <i>n</i> (%)	36 (28.6)	4 (40.0)	0.48
Hematological tumor, <i>n</i> (%)	2 (1.6)	0	0.99
Solid tumor, <i>n</i> (%)	15 (11.9)	2 (20.0)	0.61
Human immunodeficiency virus, <i>n</i> (%)	1 (0.8)	0	0.99
Renal replacement previously to ICU admission, <i>n</i> (%)	17 (13.5)	1 (10.0)	0.99
Corticosteroids previously to ICU admission, <i>n</i> (%)	14 (11.1)	1 (10.0)	0.99
Immunosuppressants previously to ICU admission, <i>n</i> (%)	10 (7.9)	1 (10.0)	0.58
Corticosteroids at CRI suspicion, <i>n</i> (%)	44 (34.9)	4 (40.0)	0.74
Parenteral nutrition at CRI suspicion, <i>n</i> (%)	17 (13.5)	3 (30.0)	0.17
Propofol at CRI suspicion, <i>n</i> (%)	69 (54.8)	8 (80.0)	0.19
Deaths at 30 d of CRI suspicion, <i>n</i> (%)	9 (7.1)	0	0.99

COPD: Chronic obstructive pulmonary disease; ICU: Intensive care unit; CVC: Central venous catheter; CRI: Catheter-related infection.

Table 2 Maki and vortexing results to diagnosis catheter tip colonization

	Maki +	Maki -	Total
Vortex +	18	0	18
Vortex -	3	115	118
Total	21	115	136

superior to the Maki method[9]. However, this study did not compare the combined use of the vortexing and Maki techniques with respect to the Maki technique alone for the diagnosis of CTC and CRBSI, and this was the novel aim of our study.

We no found any CTC or CRBSI detected by vortexing technique and not detected by Maki technique. No differences had in the comparison of AUC between the technique of Maki technique and the combination of techniques, between the techniques of Maki and vortexing, and between the vortexing technique and the combined techniques for the diagnosis of CTC or CRBSI. Thus, the novel finding of our study was that the use of vortexing combined with the Maki technique did not add any cost-effectiveness for the diagnosis of CTC or CRBSI.

Table 3 Maki and vortexing results to diagnosis catheter-related bloodstream infection

	Maki +	Maki -	Total
Vortex +	9	0	9
Vortex -	1	126	127
Total	10	126	136

Recent guidelines suggest similar recommendation strength and evidence quality for the techniques of Maki and vortexing for the diagnosis of CRI[10,11]. We think that the Maki technique remains the standard technique for the diagnosis of CTC and CRBSI due to the findings of our study and those from the study by Bouza *et al*[9], and because of the greater simplicity of the Maki technique; in addition, we think that the technique of vortexing did not provide profitability to the technique of Maki to the diagnosis of CTC and CRBSI due to the findings of our study.

We want to acknowledge that one limitation of our study was that we have not carried out other quantitative techniques (as sonication or flushing) to compare the profitability of all of them for the diagnosis of CTC and CRBSI. Another limitation of our study was that we have not reported the proportion of CVC excluded (because we did not have complete information on culture with Maki technique, culture with vortexing technique and blood culture). Another limitation of our study was the relatively low number of patients; however, our study showed that to add vortexing technique to Maki technique for the diagnosis of CTC or CRBSI do not apport any benefit due to none of them were detected only by vortexing technique and there were no differences in the AUC when vortexing technique was added to Maki technique.

CONCLUSION

The novel finding of our study was that the combined use of vortexing and Maki techniques did not provide profitability to the technique of Maki alone to CRBSI diagnosis.

ARTICLE HIGHLIGHTS

Research background

A previous study compared the vortexing and the Maki techniques for the diagnosis of catheter-related bloodstream infection (CRBSI), and concluded that vortexing was not superior to the Maki method.

Research motivation

The above study did not compare the combined use of vortexing and Maki with respect to the Maki technique alone for the diagnosis of catheter tip colonization (CTC) and CRBSI.

Research objectives

To determine whether the combined use of vortexing and Maki techniques provide profitability to the Maki technique alone for the diagnosis of CTC and CRBSI.

Research methods

Observational and prospective study. We included patients admitted in one Intensive Care Unit that had suspicion of catheter-related infection (CRI) and with one central venous catheter for at least 7 d. The area under the curve (AUC) of the Maki technique, the vortexing technique and the combination of both techniques for the diagnosis of CTC and CRBSI were compared.

Research results

We included 136 episodes of suspected CRI. We found 21 episodes of CTC and 10 episodes of CRBSI. Of the 21 episodes of CTC, 18 (85.7%) were diagnosed by the techniques of Maki and vortexing, 3 (14.3%) were diagnosed only by the technique of Maki, and none was diagnosed only by the technique of vortexing. Of the 10 episodes of CRBSI, 9 (90.0%) were diagnosed by the techniques of Maki and vortexing, 1 (10.0%) was diagnosed by the technique of Maki alone, and none only by the technique of vortexing. No differences had found in the comparison of AUC between the technique of Maki alone and the combination of techniques for the diagnosis of CTC ($P = 0.99$) and CRBSI ($P = 0.99$).

Research conclusions

The novel finding of our study was that the use combined of vortexing and Maki techniques did not provide profitability to the technique of Maki alone to CRBSI.

Research perspectives

To study other quantitative techniques (as flushing) to compare the profitability of all of them for the diagnosis of CTC and CRBSI.

FOOTNOTES

Author contributions: Lorente L conceived, designed and coordinated the study, participated in acquisition and interpretation of data, and drafted the manuscript; Lecuona M, González-Mesa, Oliveras-Roura J, Rosado C, Cabrera P, Casal E, Mora ML and Madueño A participated in acquisition of data; Jiménez A participated in the interpretation of data; all authors revised the manuscript critically for important intellectual content, made the final approval of the version to be published and were agreed to be accountable for all aspects of the work.

Institutional review board statement: The Institutional Board of Hospital Universitario de Canarias (San Cristóbal de La Laguna) approved the study protocol.

Clinical trial registration statement: This study is registered at <https://www.clinicaltrials.gov/>. The registration identification number is NCT06216184.

Informed consent statement: All study participants, or their legal guardian, provided informed written consent prior to study enrollment.

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