Surveillance of central line associated bloodstream infection (CLABSI) – comparison of current (CDC/NHSN) and modified criteria: A prospective study

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Abstract

Background and Aims: There is a huge load of central line–associated bloodstream infection (CLABSI) being reported in developing countries, with increased mortality and healthcare costs. Effective surveillance is a must to reduce the incidence of CLABSI. The current criteria (Centre for Disease Control and Prevention/National Healthcare Safety Network [CDC/NHSN]) for CLABSI surveillance have their own shortcomings. For diagnosing CLABSI, current CDC/NHSN CLABSI surveillance criteria are laborious and time consuming with low predictive power. Hence, modified criteria have been postulated, which are simple and implementable at resource-constrained setups. The primary objective was to compare modified criteria with CDC criteria. The secondary objective was to determine the prevalence of CRBSI.
Material and Methods: A total of 98 patients with central line *in situ* or having the central venous line removed ≤24 hrs prior to the date of the event were enrolled. Paired blood cultures were obtained and results were analyzed using differential time to positivity.
Results: The incidence of CLBSI was 8.16% and the device utilization rate was 11.6%. The negative predictive value of both the surveillance criteria was found to be excellent and comparable (96.2% for modified criteria and 97.1% for CDC criteria), therefore both can be used for screening purposes. AUC for current CDC/NHSN criteria was better than modified criteria (0.76 versus 0.66, $P < 0.0001$), suggesting it to be a better criterion for surveillance of CLABSI.
Conclusion: Modified criteria were not superior to CDC/NHSN criteria for surveillance. Thus, there is a scope of improving the modified criteria for the purpose of surveillance. CLBSI load was higher; CLABSI bundle for prevention is thus highly recommended.

Keywords: Catheter-Related Bloodstream Infection, central line–associated bloodstream infection, surveillance

Introduction

Central venous catheter (CVC) placement is done in critically ill patients for hemodynamic monitoring, access to infusion therapy, nutritional support, plasmapheresis, hemodialysis, and also in patients where peripheral venous access is limited.[1,2] Despite its uses, central venous catheterization poses an enormous risk of infections, particularly central line–associated bloodstream infections (CLABSIs)[3] and mechanical complications,[4,5] thus causing longer intensive care unit (ICU) stay and even mortality. CLABSI rates in limited-resource countries like ours are much above than those in developed countries. Thus, it is imperative to have more epidemiological studies, so as to improve surveillance in

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Access this article online	
Quick Response Code:	**Website:** https://journals.lww.com/joacp
	DOI: 10.4103/joacp.joacp_393_21

order to formulate more definitive approaches for CLABSI prevention that can be easily implemented.

Implementing CLABSI surveillance criteria by standard Centre for Disease Control and Prevention/National Healthcare Safety Network (CDC/NHSN) can be confusing, laborious, and time consuming and also possesses low-positive predictive value for diagnosing CLABSI.[6] Modified criteria for CLABSI are defined as growth in blood culture from the samples taken from a central venous line with clinical signs and symptoms and with no other obvious causes of infection. This can be simple, cost-effective, and implementable at resource-constrained setups, and therefore must be examined.

Thus, we proposed to review the prevalence of CLABSI and to gauge if the surveillance definition from modified criteria is comparable to the of CDC/NHSN definition for CLABSI.

Material and Methods

This prospective observational study was planned in 15-bedded ICU from September 2017 to February 2019. After obtaining approval from the Institutional Ethical Committee (date of approval: 30/09/2017) and written informed consent from the patients' caregivers, 98 adult patients (>18 years) with a central venous line in place or having the central line removed ≤24 hrs prior to the date of event were included. Patients whose central venous line was removed within 48 hrs, any patient who was discharged, expired, or was transferred within 48 hrs of admission to ICU, or those not giving consent to participate in the study were excluded from the study.

Definitions as per CDC[6]
Date of event: The date of specimen collection at site-specific infection (SSI) as per the NHSN criterion, which occurred for the first time within the 7-day infection window period or SSI surveillance period.

Healthcare-associated infections (HAIs): If SSI happens on or after the 3rd day of admission to hospital.

Device-associated infection: A device-associated HAI is taken into account if the device was *in situ* for >2 days on the date of the event and was also in place on the date of the event or the day earlier.

Device days: The number of patients with the device *in situ* at patient care site during a time period.

Present on admission (POA): An infection that has a date of the event that happens on the day of admission, 2 days before admission, or the day after admission.

Repeat infection time (RIT) frame: It is the 14-day time span during which no new infections of the same type were detected.

Secondary BSI attribution period: The period in which a blood specimen is collected for a secondary bloodstream infection (BSI) that is accredited to a primary site infection. This period is ascribed as 14-17 days from the date of event.
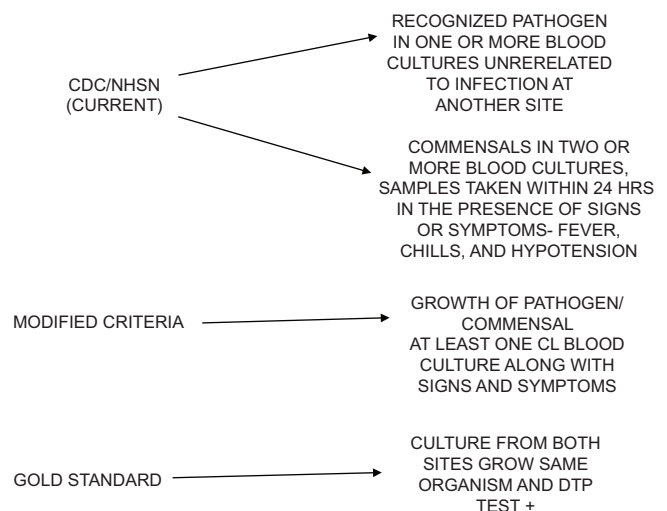
Primary BSIs: IT is the BSI that was confirmed by laboratory (LCBI) and is not secondary to an infection at any other body site.

Possibility of CLABSI was considered when the central line was in place for at least 48 hrs, and therefore the patient had developed positive blood culture and there was no other recognized cause for positive blood culture. Such patients were searched for CLABSI surveillance and surveyed on current (CDC/NHSN) and modified criteria. Infections due to pathogens and commensals were also notified. The surveillance criteria were further compared using the differential time to positivity test (DTP) to assess their relative accuracies.

Microbiological test
In the enrolled patient, after cleaning the local sites with 70% alcohol and allowing it to dry, 10 mL of blood was drawn from the central line and peripheral line and was put into blood culture containers. Blood culture results including the growth of organisms and DTP were noted for each case. DTP test was labeled positive if the difference in time to positivity of cultures from the central venous line and the peripheral line was over 120 min.

Central line–associated bloodstream infection

CDC/NHSN (CURRENT) → RECOGNIZED PATHOGEN IN ONE OR MORE BLOOD CULTURES UNRERELATED TO INFECTION AT ANOTHER SITE

CDC/NHSN (CURRENT) → COMMENSALS IN TWO OR MORE BLOOD CULTURES, SAMPLES TAKEN WITHIN 24 HRS IN THE PRESENCE OF SIGNS OR SYMPTOMS- FEVER, CHILLS, AND HYPOTENSION

MODIFIED CRITERIA → GROWTH OF PATHOGEN/ COMMENSAL AT LEAST ONE CL BLOOD CULTURE ALONG WITH SIGNS AND SYMPTOMS

GOLD STANDARD → CULTURE FROM BOTH SITES GROW SAME ORGANISM AND DTP TEST +

Data were recorded and compiled as central line/per central line days. For patients having more than one central line, it was still counted as one central line day; events/culture positives occurring on the day of central line removal or 1 day later were also included in CLABSI definitions.

Statistical analysis

Maki *et al.*[3] had reported an incidence of CLABSIs as five to eight per 1000 central line days (a). Taking this as a reference, the minimum required sample size with a 2% margin of error and 5% level of significance was 77 patients; however, 98 patients were included.

Categorical variables were presented as number and percentage (%) and continuous variables as mean ± SD and median. Inter-rater kappa agreement was determined to find the strength of agreement between current and modified criteria with gold standard DTP test. Chi-square test was done to determine the sensitivity, specificity, positive predictive value (PPV), and negative predictive value. McNemar's test was done to compare the sensitivity and specificity of current and modified criteria. A receiver operative curve was used to assess the accuracy of test. A P value of <0.05 was regarded statistically significant. The data was analyzed on Statistical Package for Social Sciences (SPSS) version 21.0.

Results

The median age of 98 patients was 45 years (IQR 26-45) and 58% were male. The median central line days was 5 (IQR 4-7) [Table 1]. Also, 53% (52/98) of patients had a growth in central line cultures. Out of 52 samples with positive cultures, 30 were pathogens and 22 were commensals. Fourteen had growth of the same organism in central and peripheral line cultures, out of which eight were DTP positive. Three out of the 14 samples were commensals and one sample showed DTP positivity. Four samples were counted as secondary BSI and were not included in either

Table 1: Demographic profile and surveillance profile

	n=98	
Age (years) Median (IQR)	40 (26-51)	
Gender		
Male	57 (58.16%)	
Female	41 (41.8%)	
Duration of central line (days) Median (IQR)	5 days (4-7)	
Bacteriological profile	52/98	30 pathogens 22 commensals
CL days Median (IQR)	5 (4-7)	

CL=central venous line

definition. Coagulase-negative staphylococci (CONS) were the commonest commensals in our study, whereas among the pathogens, *Acinetobacter*, *Candida*, and *Klebsiella* were the predominant organisms [Figures 1-3]. When CDC criteria were compared using the DTP test, they were found to be significant with inter-rater kappa agreement ($P = 0.002$)
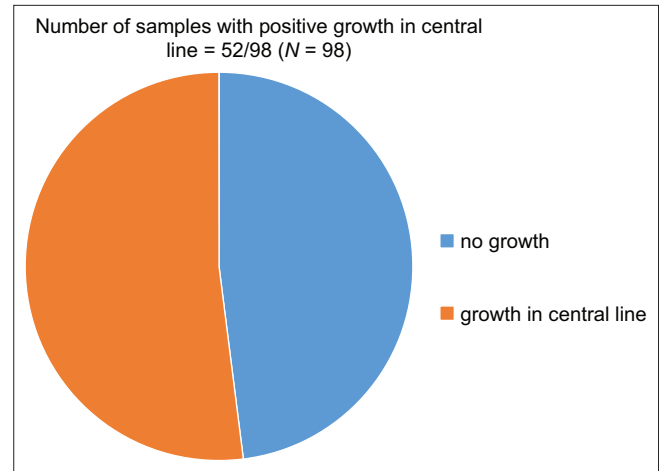

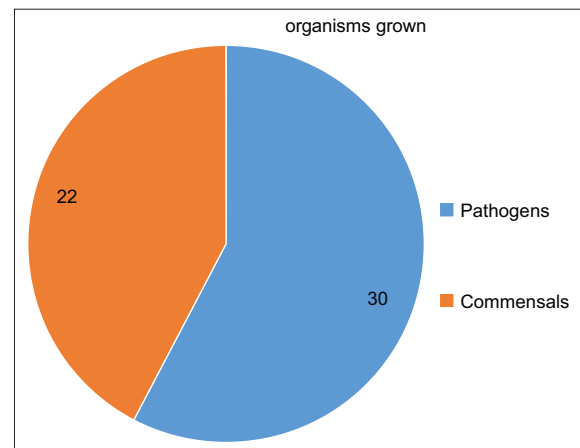**Figure 1:** Bacteriological growth in central line blood cultures

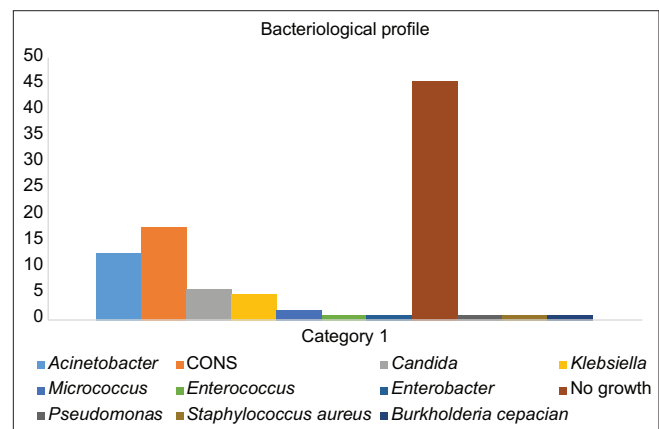**Figure 2:** Distribution of pathogens and commensals

Figure 3: Profile of bacterial growth from central line blood cultures

whereas modified criteria when compared with the DTP Test were not significant ($P = 0.085$).

When both the criteria were compared with each other, they had similar sensitivity, but the specificity of CDC criteria was found to be significantly better than the modified criteria ($P < 0.0001$). The negative predictive value of both the surveillance criteria was found to be excellent and comparable (96.2% and 97.1% for modified and CDC criteria, respectively). PPV of both tests was found to be poor (22.2% and 13.3%, respectively); however, it was lesser for the modified criteria. Accuracy of current criteria (CDC/NHSN) was found to be better than that of modified criteria (P value $= 0.0096$) [Table 2]. AUC for current CDC/NHSN criteria was better than that of modified criteria (0.76 versus 0.66, $P < 0.0001$) [Table 2 and Figure 4].

Discussion

Surveillance is the backbone to identify local problems, priorities, and to evaluate the effectiveness of infection control policies. However, in most of the hospitals, surveillance activities are passive and restricted only to the analysis of microbiological reports of diagnostic samples. CDC/NHSN criteria are the standard for the purpose of surveillance; however, they have their own limitations.

Barker *et al.*[7] showed that CLABSI was either over or underreported and there was variability in the application of NHSN surveillance criteria. According to Klompas *et al.*,[8] although surveillance using NHSN definitions is the *de facto* standard, the definitions are complicated, time

consuming, and difficult to implement and are subjected to misclassification.

Hence, to fulfill the needs of a simpler surveillance definition, modified criteria were suggested, which could be better suited for resource-poor countries. In this criterion, single blood culture positivity from a central line sample was only required along with clinical signs and symptoms.

In our study, blood samples drawn from central or peripheral lines of all patients were put in both the criteria (for surveillance) as per the clinical signs and symptoms. DTP was noted using an automated, continuously monitored blood culture system if the same organism grew in both cultures (peripheral and central lines) and a difference in time to positivity of 120 min or more was considered as the gold standard test for the diagnosis of CLABSI.

Prevalence of CLABSI

The prevalence of CLABSI was 8.16% in our study. The higher rate of CLABSI in our study could be due to the fact that a larger number of patients had surgical illness and were taken up as an emergency procedure.[9,10] Also, in our setup, jugular venous access was preferred over subclavian; this could also explain the higher rates of CRBSI.[11]

Various authors have reported the incidence of catheter-associated bacteremia as 7.41%[12] and 2.6%.[13] Ruesch *et al.*[11] reported 8.6% CRBSI with jugular access and 4% with subclavian access. Lorente *et al.*[14] reported 2.04% CRBSI (2.79 per 1000 catheter days). Chopdekar *et al.*[15] reported an average CRBSI rate of 9.26 per 1000 catheter days, ranging from 9.26 per 1000 days to a maximum rate of 27.02 per 1000 days in neonatal ICU.

In our study, *Acinetobacter* B, *Klebsiella*, and *Candida* species were the predominant pathogens. A high rate of CONS

Table 2: Comparison of current (CDC/NHSN) and modified criteria for surveillance of CLABSI by DTP

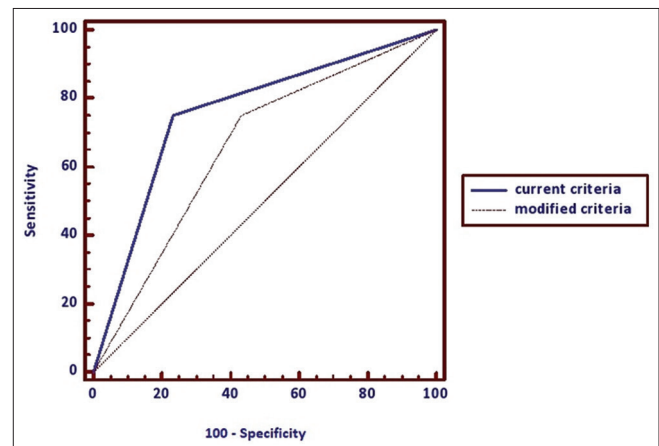| Parameter	Current (CDC) criteria	Modified criteria	P
True negative	70.14%	52.04%	
False positive	2.04%	2.04%	
True positive	6.12%	6.12%	
False negative	21.43%	39.8%	
Sensitivity 95% CI	75.00% (34.9-96.8)	75.00% (34.91-96.81)	-
Specificity 95% CI	76.7% (66.6-84.9)	56.67% (45.80-67.08)	<0.0001
Positive predictive value 95% CI	22.2% (8.6-42.3)	13.33% (5.05-26.79)	0.15
Negative predictive value 95% CI	97.2% (90.2-99.7)	96.23% (87.02-99.54)	0.978
Area under curve 95% CI	0.76 0.66-0.84	0.66 0.56-0.75	<0.0001
Positive likelihood ratio 95% CI	3.2 1.86-5.56	1.73 1.09-2.75	
Negative likelihood ratio 95% CI	0.33 0.10-1.09	0.44 0.13-1.49	

Figure 4: Receiver operative curve comparing CDC and modified criteria for CLABSI surveillance

positivity was also observed along with other commensals. Higher rates of *Acinetobacter* and *Klebsiella* may point toward antimicrobial resistance and more studies are needed in this regard.

Catheter colonization rates

The incidence of catheter colonization was 53% in our study. Similar findings were reported by Chopdekar *et al.*[15] and Karpel *et al.*[16] The higher incidence probably also indicates that our practice of sepsis prevention needs to be stricter and should follow the international standards.

Duration of catheterization

The mean duration of central line days for CRBSI in our study was 6 days. Richet *et al.*[17] reported that positive culture rate for central catheters increased significantly after 4 days of catheterization. Kaur *et al.*[18] had reported higher incidence of catheter tip infections/colonization when CVC was kept for >7 days. Unlike Charalambous *et al.*,[19] the duration of catheterization was not a predictor of infection.

In our study, when both the criteria were compared, they had similar sensitivity, but the specificity of current (CDC) criteria was found to be significantly better than the modified criteria ($P < 0.0001$). This could be because of a large number of false-positive cases due to commensals that also showed signs and symptoms as defined in the modified criteria. Only single culture positivity along with presenting clinical symptoms due to disease process contributed to low specificity and lower PPV for the modified criteria. The negative predictive values of both the surveillance criteria were found to be excellent and comparable (96.2% and 97.1% for modified and current criteria, respectively). This shows that both the criteria could be used as screening tools.

The PPV of both the tests was found to be poor (22.2% versus 13.3%); however, it was lower for the modified criteria. This was similar to that reported in other studies.[20,21] The PPV of CDC was reported to be 27.7%, which is suggestive of CLABSI rates being overestimated,[21] but was lesser than the PPV of 48.4% as reported by Chen *et al.*[22]

PPV of 13.3% found in our study for the modified criteria could be attributed to large number of single culture positivity due to commensals, thus leading to a large number of false-positive cases and overestimation of CLBSI. The positive clinical signs and symptoms associated with these may have been primarily due to the disease and may have been a confounding variable. Thus, there exists a need for a well-defined research and more objective set of clinical/lab findings for such patients. Accuracy of current criteria (CDC/NHSN) was found to better than the modified criteria (P value = 0.0096). The ROC curve

suggested that the CDC criteria (0.76 versus 0.66) are better for surveillance of CLABSI.

Limitations

Our study was limited to a single center and single reviewer. It also included small number of cases. In our study, patients were already on antibiotics, which could have affected the outcomes. Also, our study included cases where central line was placed in emergency situations, which may have affected the outcomes.

Conclusion

Modified criteria with high false-positive rates, poor specificity, PPV and poor diagnostic accuracy were not superior to CDC/NHSN criteria for surveillance of CLABSI. However, CDC definitions for surveillance of CLABSI have their own shortcomings; they are often confusing, have difficulty in differentiating primary CLABSI from secondary BSI, and have a poor PPV and variable sensitivity. The rate of CRBSI was high in our study; therefore, strict surveillance and CLABSI bundle for prevention is highly recommended.

Financial support and sponsorship

Conflicts of interest

There are no conflicts of interest.

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