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Effect of central line bundle implementation on central line-associated bloodstream infection rates in NICU in KSA

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Abstract
Central line-associated bloodstream infections (CLABSI) remained a significant cause of mortality and morbidity in neonatal patients admitted to the neonatal intensive care unit (NICU) who require central line (CL) insertion for whatever medical reason. Recent introduction of CL bundle strategies was associated with a drop in the CLABSI rates. Data about the effect of CL bundle on the rate of CLABSI in neonatal patients in Saudi Arabia are lacking. In this prospective targeted surveillance study, we examined the association between insertion-focused Institute for Healthcare Improvement (IHI) CL bundle implementation and the incidence rate of CLABSI in a NICU in a tertiary teaching hospital in Saudi Arabia during the period between 2009 and 2011. We looked also at the rate of compliance with the CL bundle. The results showed a statistically significant decrease in umbilical catheter-related BSI rate (p= 0.048). Other types of CLs did not show any statistically significant association. The overall CL bundle compliance was below the targeted rate adopted by the IHI. Further efforts towards increasing compliance with CL bundle strategies and reducing the use of CLs is needed to further decrease the current rates of CLABSI in our NICU. Other factors contributing to the development of CLABSI, which were not explored in this study, need to be examined as well.

Keywords: healthcare-associated infection, central-line associated bloodstream infection, prevention, bundle, paediatrics, neonatal intensive care.

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Background

Several studies showed that healthcare-associated infections (HAIs) are recognized causes of mortality, morbidity and excess cost and length of stay in the Neonatal Intensive Care Unit (NICU).[1-5] Neonates admitted to NICU are at a major risk of acquiring HAIs because of the immaturity of their immune system and the intensive use of medical devices.[6-7] Recently, and as the result of improved survival of the very low birth weight neonates and their need for more sophisticated and invasive interventions, the number of these neonates who acquire HAI including CLABSI increased significantly.[8]

The concept of 'Care Bundles' was initiated for the first time by the Institute of Healthcare Improvement (IHI) and since then is recognized as an important quality improvement method aimed at reducing the rate of CLABSI and other HAIs.[9] The Central Line (CL) Bundle is a group of evidence-based interventions applied for patients who have one or more intravascular CLs. These interventions are believed to lead to better outcome when they are implemented together, than when they are implemented individually. The components of this CL bundle are hand hygiene, maximal barrier precautions, chlorhexidine skin antisepsis, optimal catheter site selection and daily review of CL necessity.[10]

Data about the rate of CLABSI in NICUs in Saudi Arabia are limited. Moreover, studies on the effect of the CL bundle on the rate of CLABSI in neonatal population are lacking. Furthermore, information about the rate of compliance to the CL bundle is also lacking. However, a number of international studies showed the effectiveness of these CL insertion and maintenance bundles on CLABSI rate in NICUs.[11] Our aim was to estimate the rate of CLABSI and the compliance rate with the CL bundle in one NICU in a large teaching tertiary hospital in Saudi Arabia and to examine the association between CL bundle implementation and the rate of BSI in this ICU.

Methods

Setting: The current study was conducted in the NICU of King Abdulaziz Medical City (KAMC) in Riyadh, Saudi Arabia. It is a 40-bed level II/III NICU that serves premature and high risk neonates. KAMC-Riyadh is an approximately 900-bed tertiary care facility that provides healthcare services to about 600,000 Saudi National Guard soldiers, employees and their families. Almost 18% of the bed capacity of the KAMC-Riyadh is allocated for critical care with 11 different types of ICUs.

Study population: All neonates who were admitted to the NICU of KAMC-Riyadh between January 2009 and December 2011 and required insertion of CL for any medical reason were included in this study. Neonates with a CL that was inserted in another hospital or was inserted in our hospital but remained for less than 48 hours after admission were excluded from the study. Since we are logistically not able to follow patients between hospitals, we only included those who are seen at our hospital.

Study design: The data of this study were collected based on two different study designs. First, prospective targeted surveillance was conducted to estimate the rate of CLABSI in NICU during the study period (2009-2011). Second, a cross-sectional study was completed to assess compliance to the CL bundle starting after bundle implementation in January 2010 through the end of the study (December 2011).

Surveillance definitions: The definition of CLABSI implemented was based on the NHSN definitions that remained essentially unchanged during the surveillance period covered.[12] CLABSI was defined as a laboratory-confirmed bloodstream infections that was not secondary to an infection at another body site, in a patient who have CL or umbilical catheter in place at the time of, or within 48 hours before, onset of the event. The bloodstream infections was established by detecting recognized pathogen in one or more blood cultures or by detecting common skin contaminant in two or more blood cultures supplemented by infection symptoms. These include fever, hypothermia, apnoea, or bradycardia.

Data collection: CLABSI data were collected using the same methodology adopted by the US NHSN (12). These included numerator data (patient demographic, CL information and diagnosis of CLABSI event) and denominator data (the daily number of neonates as well as those with CL or umbilical catheter). The CL bundle data were collected using the same methodology adopted by the IHI.[13] The bundle is insertion-focused and included hand hygiene, maximal barrier precautions, chlorhexidine skin antisepsis, optimal catheter site selection and daily review of CL necessity. Compliance with individual CL bundle components as well as all components together was recorded.

Duration and methods of implementation of CL bundle: CL bundle was implemented starting January 2010. Therefore, before implementation means 2009 and after implementation means 2010-2011 data. Data were recorded in the patient file by the treating physician or nurse. Infection control staff make live auditing and discussion with the treating staff but he/she was giving feedback only on what they have already recorded.

Data analysis: CLABSI rate was calculated as the number of CLABSI events per 1000 CL days. CL bundle compliance rate was calculated as the total number of compliant days (individual and combined) divided by the total number of those examined for CL compliance and the result was expressed as percentage (%). Comparison of CLABSI rates before and after implementation of CL bundle was calculated using the rate difference and rate ratio and the significant difference was tested using z-score. All tests were two-tailed and p value of <0.05 was considered to be statistically significant. SPSS software (release 20.0 SPSS Inc., Chicago, U.S.) was used for statistical analyses.

Results

During our study, the total number of neonates admitted to NICU was 1126. Out of these, 251 neonates required CL insertion (Table I). The majority of neonates with CL required admission for more than 7 days (91.6%) and most of them required more than one CL (62.7%). Among CLs used, the majority were

Table I. Demographic and clinical characteristic variables for NICU patients with central lines during the study period (2009-2011)

	N	%
Gender		
Male	128	51
Female	123	49
NICU stay		
< 7 days	19	8.4
>= 7 days	207	91.6
No. CVC* lines		
1 line	94	37.3
2 and more	158	62.7
Catheter Type		
Umbilical Catheter	199	79.6
Central Line	51	20.4
Total No. of		
CL days	3355	
Umbilical days	2494	
CLABSI Events		
CL associated	8	40
Umbilical associated	12	60

* CVC (Central Venous Catheter)

Table II. CLABSI rate before and after CL bundle implementation in NICU 2009-2011

	CLABSI Rate				**Rate Comparison**				**z-score**	**p-value**
	Before (2009)		After (2010-2011)		Rate Ratio		Rate Difference			
	Rate	95% CI	Rate	95% CI	value	95% CI	Value	95% CI		
CL	3	0.798 - 7.597	2	0.536 - 5.102	0.672	0.168 - 2.685	-0.974	-4.477 - 2.528	0.57	0.571
UC	8.2	3.559 - 16.280	2.6	0.705 - 6.711	0.317	0.095 - 1.053	-5.643	-11.92 - 0.633	1.98	0.048

CL: Central Line;
UC: umbilical catheter

umbilical catheters (79.6%). Overall, 20 CLABSI events were documented during the 3 years surveillance period, accounting for 8% of the total number of neonates who required CL insertion. Of the diagnosed cases, 60% were associated with Umbilical catheters. The ratio of umbilical catheter days to CL days was 0.7:1 (2494 and 3355 respectively).

Figure 1 represents the CLABSI rate in NICU according to the catheter type. For CLs, CLABSI rate showed steady increase during 2009. Starting from third quarter of 2010, CLABSI rate showed steady decrease. The overall CLABSI rate was higher in cases of umbilical catheter compared to CLs. The same figure also illustrates the overall compliance to CL bundle components starting from quarter 1 in 2010.

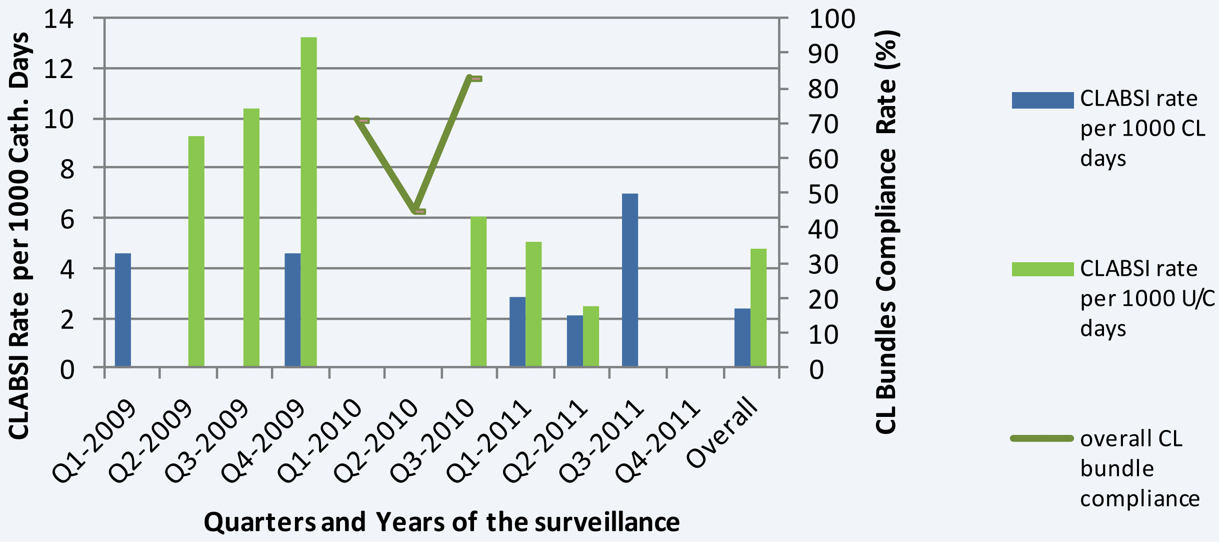
Figure 2 illustrates the compliance rate with each of the CL bundle components during the study period after the CL Insertion Bundle implementation took place. Most of the bundle components compliance rates are above 80%, especially starting from the third quarter of 2010. There was some drop in the compliance rate of all components during the third quarter of 2011 except for the daily review of the catheter necessity.

During the study, CL-BSI rate had reduced from 3 to 2 per 1000 CL days after CL bundle implementation (Table II). This reduction was not statistically significant. On the other hand, umbilical catheter-associated BSI rate had reduced from 8.2 to 2.6 per 1000 umbilical catheter days. This reduction was statistically significant (p= 0.048) (Table II).

Discussion

CLABSI still a problem in our NICU population. Our CLABSI results are higher than results reported by the NHSN 2009 report,[14] possibly due to slightly higher level of CL utilization ratio in our study that we examined but could not benchmark it to NHSN data due to reasons that will be mentioned in the limitation section below. Other possible reasons are the presence of other risk factors related to the occurrence of CLABSI which we did not examine in this study. Some of these risk factors are catheter insertion location, catheter maintenance, co-morbidity and type of feeding. On the other hand, CLABSI incidence rate in our NICU was lower than rates reported in studies done in some developing countries,[15-16] perhaps because of better health care resources in Saudi Arabia.

In our study, we demonstrated that implementation of CL insertion-focused IHI CL bundle strategy was associated with a decrease in CLABSI rate in NICU. Although this implementation was associated with decrease in BSI rate with both CL and umbilical catheters, this decrease was only statistically significant in case of umbilical catheter- associated BSI (p=0.048). This may be explained by the obviously high BSI rate before the implementation of CL bundle



CLABSI: Central Lines-Associated Bloodstream Infection; CL, central line; U/C, umbilical catheter.

Figure 1. CLABSI Rates in NICU during the study period (2009-2011) and overall CL bundle compliance after implementation

(during 2009). This high rate of BSI before CL bundle implementation could be related to high number of low and very low birth weight babies who usually stay longer in NICU and require more invasive procedures during the course of hospitalisation, like insertion of umbilical catheters and CLs, which make them more vulnerable to infections as shown by several studies.[17-20] This statistically significant association is perhaps because the rate before CL bundle implementation was significantly high, so one would expect that implementation of appropriate infection control measures would help in reducing the rate of BSI even if the compliance is not that high. The overall CL bundle compliance was below the goal set by the IHI (which was set at more than 95%).[13] The drop of overall CL bundle compliance during second quarter of 2010 (Fig.1) was mainly due to the drop in compliance with chlorhexidine use (Fig. 2).

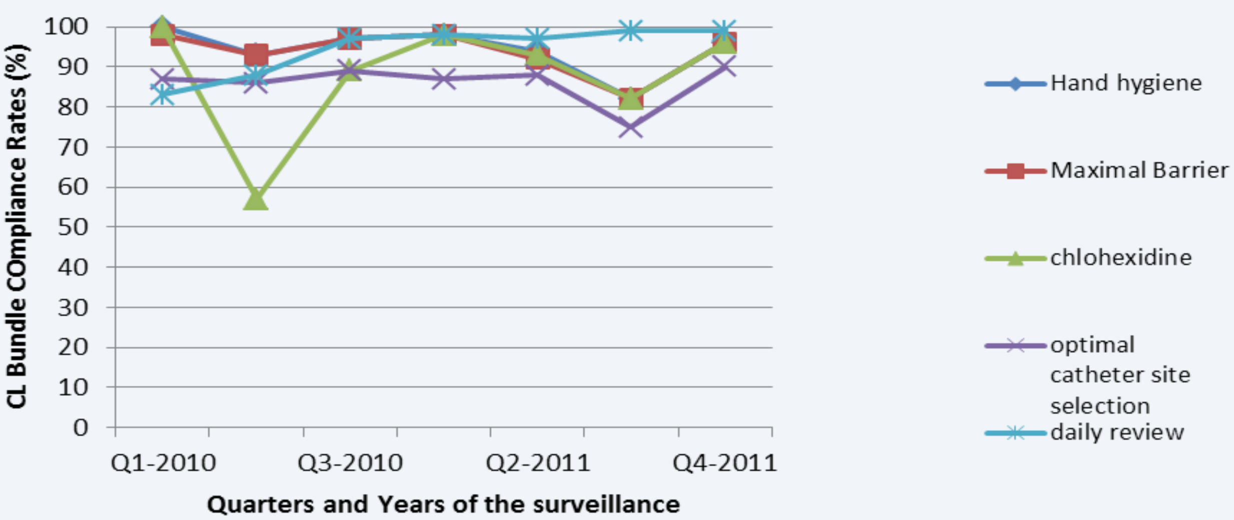


Figure 2. Central lines bundles insertion and maintenance compliance rate (%) for NICU (2010-2011)

Several studies in both neonatal and adult populations have shown the effectiveness of implementing proper CL insertion bundle in decreasing the incidence rate of CLABSI especially when the compliance rate to this care bundle is high.[21-23] In our study we showed that implementation of the CL insertion bundle in 2010 was associated with a statistically significant decrease in umbilical catheter-associated BSI. It is to be noted that the insertion-focused IHI CL bundle are only few measures out of all potential factors for preventing CLABSI. This may at least explain why we could not find an impact of bundle compliance on the rate of BSI associated with CL. Another critical point was that any expected improvement in the CLABSI rate would require a sustained high compliance (above 95% according to the IHI objectives) of all bundle components together. Since we did not achieve such high compliance rate among all components combined, this may at least explain why we could not find a strong impact of insertion bundle compliance on the BSI rate associated with CL.

Study Limitations

This study has some limitations which were beyond our control. There were some periods during the surveillance for which there were no data collected. This is because of the nature of this type of surveillance (prospective targeted surveillance). The study design did not allow us to study whether the statistically significant improvement in umbilical catheter-associated BSI after the implementation of the CL bundle is merely due to the implementation of this program or other non-measured contributing factors. The data represent one centre's experience with the possibility of limited generalisability. The data of the study are considered aggregate data which are liable to ecological bias. This particular limitation could be addressed by future studies through conducting patient-based research that collects individual data on both CLABSI development and CL bundle compliance. We could not benchmark this data to NHSN data because the methods of collecting data/definitions are not the same (NHSN had in the period of 2009-2011 included all patients with CL, irrespective of where it had been inserted and also they had no 48 hour limit). Second, we could not compare one NHSN year with three years from our study.

Conclusions

We demonstrated that implementation of insertion-focused CL insertion bundle strategies was associated with a decrease in umbilical catheter associated BSI rate in NICU. The overall CL bundle compliance was below the targeted rate adopted by IHI. Further efforts need to be adapted in order to increase the compliance rate to CL insertion and maintenance bundle strategies and to reduce the use of CLs in order to further reduce CLABSI rates. Examples of these efforts are multidisciplinary approach, staff education and accountability and catheter maintenance strategies.[24]

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