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Practice Forum

Reduction of hospital-acquired infections in the neonatal intensive care unit: A long-term commitment

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Very low birth weight

We instituted quality improvement program. We compare the infection rate before (2011-2012) and after (2013-2015). Central line associated blood stream infection episodes decreased from 15.2 to 2.29 episodes per 1000 catheter days ($P = .004$). We found two major changes, 1. Hand hygiene increased mainly "before aseptic task", from 69.9% to 89.9% and 2. A significant decrease in the length of the catheter use from 5.4 ± 4.5 before to 4.4 ± 2.5 days after the intervention ($P = .001$).

Late onset sepsis (LOS) is a major cause of mortality and morbidity in neonatal intensive care units (NICU).[1-3] Preterm and sick infants are at particular risk because they have an immature immune system, immature gut, and deficient barrier function of the skin.[4,5] Also, they often require central lines to deliver parenteral nutrition, which further increases the risk for LOS.

Many efforts have focused on reducing the rate of LOS. In our unit, we have previously achieved a reduction in infections that was primarily related to early aggressive enteral feeding and reduced use of total parenteral nutrition.[6] However, in 2011-2012, we specifically evaluated the rate of central line–associated bloodstream infection (CLABSI), which was found to be unacceptably high. As a result, we instituted a multifaceted quality improvement (QI) program that began in 2013.

Previously demonstrated in the case of central lines, bundling groups of potentially best practices has been shown to result in better outcomes than when practices are implemented individually.[7] The components of the bundles described in previous studies, and which we adopted, included the use of maximum sterile barrier precautions for line insertion, optimal hand hygiene practices, and daily reassessment of the need for a central line.

METHODS

Study design and interventions

This was a quasi-experimental study to compare CLABSI and LOS rates before (2011-2012) and after (2013-2015) the QI program. Data were collected on all neonates with either LOS or with central lines with regard to the type of line, length of use, and evidence of infection.

The QI program included the following components:

1. Every three months, the infectious disease and NICU leadership teams met to review hand hygiene and infection rates and implementation issues. Findings were then presented to the rest of the NICU team. All staff, and nursing in particular, were empowered to stop procedures that breached guidelines.
2. In order to monitor and to ensure maximal barrier precautions we implemented a check list for auditing the insertion of central lines. The preparation and the process of line insertion were monitored with deviations from protocol being corrected at the time of the procedure.
3. Strict supervision of hand hygiene, with attention to the "five steps" rule. The "five steps" for hand hygiene was repeatedly explained to the team, and suggestions for improvement were offered during the team meetings. Supervision on the process of central line insertion and supervision on routine catheter care was routinely done.

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4. "Stop the line:"
   A. On work rounds, the necessity for the central line was re-assessed daily.
   B. The routine feeding protocol included early aggressive enteral feeding.
   C. Limiting length of use of umbilical venous catheters by changing to a percutaneously-inserted central catheter at age 5-7 days.

The primary outcome variable was the CLABSI rate per 1,000 central line days and bloodstream infection (BSI) and total nosocomial sepsis rates per 1,000 hospital days before and after the QI. The secondary outcome was the same but for very low-birth-weight infants (VLBW <1500 g). The local and national institutional review board approved the data collection.

Statistical analysis

Data were analyzed using SPSS Statistics software version 20 (SPSS, IBM, Armonk, NY). Comparisons of categorical variables, such as CLABSI rates, were performed using the χ^2 test. The Student t test was used to compare means of continuous variables. Risks were compared using odds ratios (OR) and 95% confidence intervals (CI). A 2-tailed *P* value <.05 was considered statistically significant for all analyses. The data were collected prospectively and analyzed retrospectively.

Definitions and unit routine

The Centers for Disease Control and Prevention definition of CLABSI[8] is primary BSI associated with the presence of a catheter at the time of, or shortly before, the onset of an infection or up to 48 hours after removal of the line. The organism identified in the blood must not be related to infection at another site. BSI is defined as a positive blood culture after the age of 72 hours, except for coagulase-negative *Staphylococcus* sepsis, in which 2 positive blood cultures are drawn on separate occasions were needed. BSI was not associated with CLABSI. Central line is defined as an intravascular catheter terminating at or close to the heart or in 1 of the great vessels and included an umbilical venous catheter (UVC), umbilical arterial catheter, or percutaneously-inserted central catheter (PICC). Each case of sepsis was independently reviewed by the infectious disease team and the bacteriology laboratory team and was classified according to the Centers for Disease Control and Prevention criteria.[9]

Use ratio was calculated as the ratio between catheter days and hospital days in the NICU.

Setting

This QI program was conducted in the NICU at Kaplan Medical Center, Rehovot, Israel, which is a 20-bed, inborn tertiary unit that provides a full range of neonatal and surgical services. Approximately 7,000-7,500 infants are delivered annually in the hospital.

RESULTS

Study population

During 2011-2015, 1,451 infants were hospitalized in the NICU. Six hundred sixty-two central lines were inserted in 367 (25.3%) infants. The pre-QI and post-QI groups were similar with respect to birth weight (BW) and gestational age (GA). The pre-QI group included 141 infants with central lines with a mean BW of 1,846 ± 1,062 g and GA of 31.9 ± 6 weeks. The post-QI group included 226 infants with central lines and had a BW of 1,958 ± 1,074 g and GA of 32.5 ± 5.6 weeks (*P* = .331 and .371, respectively). We inserted 258 (mean of 129 per year) central lines before and 404 (mean of 135 per year) after the intervention.

Table 1
Rate of infections before (2011-2012) and after (2013-2015) the quality improvement program

	2011-2012	2013-2015	*P*
CLABSI episodes per 1,000 CL days (n)	15.2 (15)	2.29 (4)	.004 OR = 0.198
BSI episodes per 1,000 hospital days (n)	1.43 (17)	0.79 (16)	.561 OR = 0.499
Total sepsis episodes (n) per 1,000 hospital days	2.69 (32)	0.98 (20)	.317 OR = 0.333
% of CLABSI (number of sepsis episodes [n]*100 number of CLs)	5.81 (15)	0.99 (4)	.054 OR = 0.158
% of total sepsis (number of sepsis episodes [n]*100 number of patients)	5.6 (32)	2.59 (20)	.149 OR = 0.319

BSI, bloodstream infection; *CL*, central line; *CLABSI*, central line–associated bloodstream infection.

Rate of infections

After the QI program, the number of CLABSI episodes per 1,000 catheter days decreased by 84% from 15.2-2.3 (*P* = .004; OR 0.2). The rate of total sepsis decreased from 2.7-1 per 1,000 hospital days (*P* = .317; OR 0.3) and the rate of BSI decreased from 1.4-0.8 episodes per 1,000 hospital days (*P* = .561; OR 0.499) (Table 1).

The rate of all sepsis in VLBW infants decreased from 21%-9% (*P* = .002; OR 2.83) and the rate of sepsis episodes decreased from 4.1-1.7 episodes per 1,000 hospitalization days (*P* = .413; OR 0.49). The CLABSI rate decreased from 22-1.4 per 1,000 catheter days (*P* = .0003; OR 0.5) or from 10%-0.5% of VLBW infants (*P* = .003; OR 2.2). The rate of BSI in VLBW infants decreased from 8.5%-8% (*P* = .39; OR 1.4). The total number of infants who had central lines inserted increased by 6.4% over the QI period from 141 in the pre-QI group (mean of 71 infants per year) to 224 infants (mean of 75 infants per year) in the post-QI group (*P* = .74; OR = 0.96; 95% CI, 0.75-1.22). Catheter days increased by 4% from 258 days (mean 129 days per year) to 404 days (mean of 134.6 day per year, *P* = .25; OR = 1.09; 95% CI, 0.93-1.28). Neither comparison was statistically significant.

Hand hygiene

As of 2012, nurses from both the NICU and the infection control unit initiated strict supervision of hand hygiene. The observations were "open" as the working team knew that they were being observed. The number of observations gradually increased from 78 in 2012, 370 in 2013, 707 in 2014, and 2,041 in 2015. As shown in Figure 1, hand hygiene compliance increased from 2012.

Five moments for hand hygiene

As of 2013, the team began to supervise hand hygiene according to the "five moments" principle (Fig 2). As shown in Table 2, the main increase was seen "before the aseptic task" as the rate of handwashing increased from 70%, 74%, and 90% in 2013, 2014, and 2015, respectively. Auditing the insertion process of central lines began during 2013. The rate of auditing the insertion process increased from 61% in 2013 to 94% in 2015.

Types and duration of catheter types

We inserted 662 central lines, 258 (mean of 129 per year) in the pre-QI period and 404 (mean of 135 per year) in the post-QI period. There was a modest but significant decrease in the length of the catheter use from 5.4 ± 4.5 before to 4.4 ± 2.5 days after the intervention (*P* = .001).

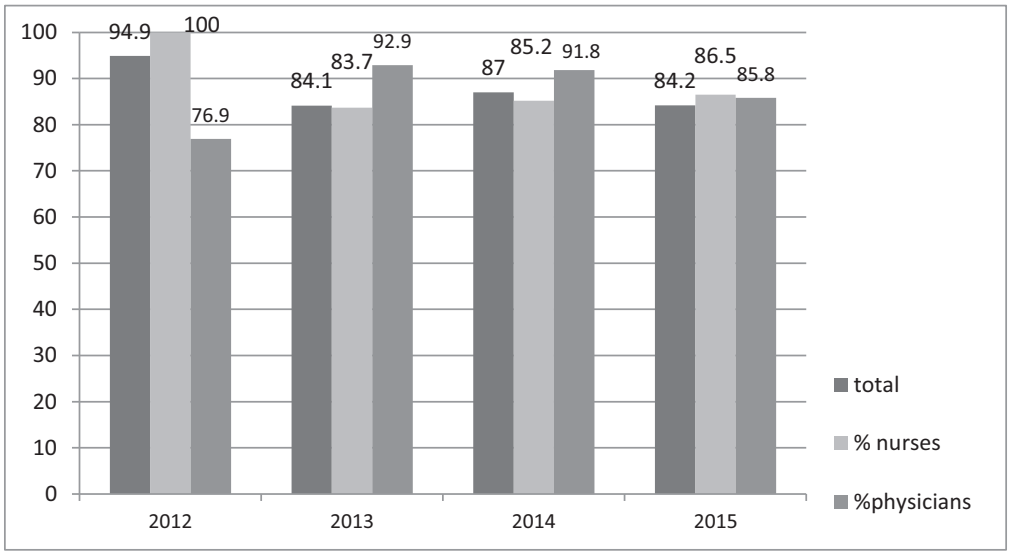

Fig. 1. Percent of hand hygiene (HH) compliance (total includes all caregivers). Number of observations: 2012 (N =78), 2013 (N = 370), 2014 (N = 707), and 2015 (N = 2,041). The rate was calculated as HH complete adherence and HH opportunities.

CLABSI versus BSI

Infants that developed BSI were smaller and more premature than those who developed CLABSI. There were 19 episodes of CLABSI in 19 infants with a mean BW of 1,471 ± 1,265 g and GA 28.9 ± 6 weeks, and there were 33 episodes of BSI in 28 infants with a BW of 863 ± 457 g and GA of 25.8 ± 3.6 weeks (BW, $P = .017$; GA, $P = .032$). The age at LOS was significantly later in the group of infants with CLABSI (24 ± 32 days) as compared with infants with BSI (9.8 ± 5.5; $P = .016$).

In the pre-QI period, our routine practice was to leave UVCs in situ for up to 2-3 weeks, if necessary. There were 15 episodes of CLABSI, 14 involving umbilical catheters and only 1 was associated with a PICC and the mean age of sepsis was 9.5 ± 4.9 with a median of 8 days. In the post-QI period, this practice changed, and umbilical catheters were removed at age 5-7 days and replaced with a PICC, as required. In this period, there were 4 episodes of CLABSI, 3 were associated with umbilical catheters at a mean age of 6-8 days.

DISCUSSION

The QI program resulted in a decrease of 84% in CLABSI episodes. The QI program included many bundles and the process demanded recruitment of the NICU team and the infectious control team. Most of the bundles are difficult to measure. Payne et al[10] conducted a systemic review and meta-analysis and showed that there is substantial experimental evidence that care bundles may reduce CLABSI rates in the NICUs, although it is not clear which bundle elements are effective in specific settings. Of the bundle components that can be measured, hand hygiene is prominent,[11,12] although our data did not show a significant increase in overall hand hygiene. A possible explanation for our improved results without an improved rate of hand hygiene may be found in the increased number of observations from only 78 observations in 2012 to 2,041 in 2015. The second possible explanation is the increase in handwashing at the second moment "before aseptic

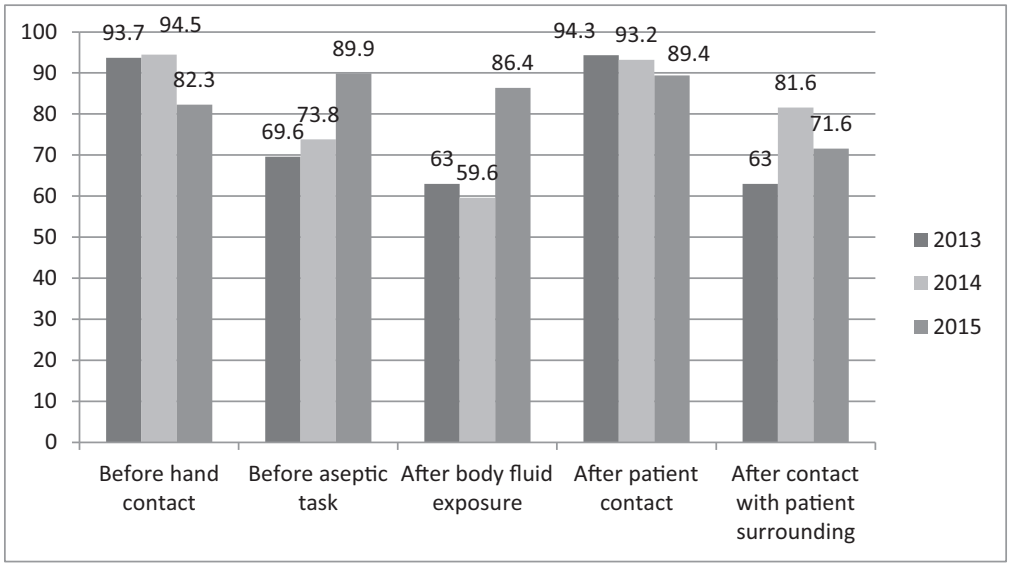

Fig. 2. "Five moments for hand hygiene" 2013-2015. The rate was calculated as HH complete adherence and HH opportunities.

Table 2
Types and duration of catheter types before and after the quality improvement program

	2011-2012	2013-2015	*P*
Number of CLs	258	404	
CL use in days (range)	5.4 ± 4.5 (1-34)	4.4 ± 2.5 (1-22)	.001
Number of UAC	105	156	
UAC use in days (median)	4.66 ± 3.5 (4)	3.69 ± 1.8 (3)	.01
UVC	125	204	
UVC use in days (median)	5 ± 3.2 (5)	4.46 ± 2.0 (4)	.067
PICC	28	44	
PICC use in days (median)	9.9 ± 8.7 (7)	6.5 ± 4.7 (5)	.064
Use ratio[#]	2012 2013 2014 2015		
	0.1 0.06 0.05 0.05		

CL, central line; *PICC*, peripherally-inserted central line; *UAC*, umbilical arterial catheter; *UVC*, umbilical venous catheter.
[#]Number of central line days/number of patients days.

task" that increased from 70%-90%. Sastry et al[13] reported that moments 3 and 4 showed statistically significant higher compliance compared with moments 1, 2, and 5. By comparison, we showed that moment 2 had a very low compliance and education helped to change that. This is an important observation. As shown before,[14,15] the appointment of a unit-based infection control nurse, education for physician and nurses, and real-time feedback on hand hygiene may lead to decreased CLABSI and LOS rates.

The duration of use of all types of catheters, mainly UVC use, decreased after the QI intervention (Table 2). The early removal of umbilical arterial catheters are used to take blood gases-meaning arterial PCO_2 levels, we switched it to capillary PCO_2 and use of skin detectors of PCO_2. The earlier removal of UVCs was achieved by more rapid advancement of enteral feeding, as tolerated, and earlier use of PICC insertion.

This raises the question whether the use of PICC instead of UVC can further decrease the rate of CLABSI. In contrary to our decision to change from UVC to PICC on day 5-7, Shalabi et al[16] compared the rate of CLABSI in preterm infants (<30 weeks) who received either PICC or UVC immediately after birth. In this retrospective study, they reviewed 540 preterm infants and found no significant differences between UVC (9.3 episodes per 1,000 catheter days) and PICC at day 1 of life (7.8 episodes per 1,000 catheter days) or UVC on day 1 that was changed for a PICC after 4 or more days (8.2 episodes per 1,000 catheter days). In their study, catheter days were significantly higher in both groups compared with the UVC alone group, and there was a relatively high rate of CLABSI. By comparison, Yumani et al[17] showed that UVCs carry the highest CLABSI rate and that longer umbilical catheter dwell-time was a risk factor for CLABSI. They recommended retaining the UVC for <1 week. Sanderson et al,[18] in a retrospective analysis of prospectively collected population data from Australian NICUs, confirmed that CLABSI risks rise with increasing central vein catheter (UVC or PICC) time, and they also supported elective UVC removal or replacement prior to day 4. They showed that CLABSI risk had a smaller rise by day 6, than plateaued thereafter, lending no support to a policy of elective removal in infants within the first 3 weeks. This study included 3,985 infants who had UVC or PICC inserted between 2007-2009, 1,392 had only UVC, 1,317 PICC only, and 1,276 had both. There were 403 CLABSI among 6,000 venous catheters reaching a total of 43,302 catheter days. CLABSI rates were higher in the group that had both UVC and PICC. In the group that had UVC and PICC, replacing UVC electively before day 4 had a trend to lower CLABSI risk than a later replacement.

O'Grady et al[19] declared in the guidelines for prevention of intravascular catheter-related infections that "Umbilical venous catheters should be removed as soon as possible when no longer needed but can be used up to 14 days if managed aseptically."

We found that during the pre-QI period, we had 15 episodes of CLABSI, 14 of them involved umbilical catheters and only 1 was associated with PICC; mean age of sepsis was 9.5 ± 4.9 with a median age of 8 days. We suggest that part of the decrease rate of CLABSI during 2013-2015 was related to earlier removal of UVCs.

CONCLUSIONS

We showed that a dedicated QI program may reduce CLABSI rates. The most likely contributing factors are earlier UVC removal and improved hand hygiene compliance before aseptic procedures.

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