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Major article

Central line–associated blood stream infections in pediatric intensive care units: Longitudinal trends and compliance with bundle strategies

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Background: Knowing the temporal trend central line–associated bloodstream infection (CLABSI) rates among U.S. pediatric intensive care units (PICUs), the current extent of central line bundle compliance, and the impact of compliance on rates is necessary to understand what has been accomplished and can be improved in CLABSI prevention.

Methods: This is a longitudinal study of PICUs in National Healthcare Safety Network hospitals and a cross-sectional survey of directors and managers of infection prevention and control departments regarding PICU CLABSI prevention practices, including self-reported compliance with elements of central line bundles. Associations between 2011-2012 PICU CLABSI rates and infection prevention practices were examined.

Results: Reported CLABSI rates decreased during the study period, from 5.8 per 1,000 line days in 2006 to 1.4 in 2011-2012 ($P < .001$). Although 73% of PICUs had policies for all central line prevention practices, only 35% of those with policies reported ≥95% compliance. PICUs with ≥95% compliance with central line infection prevention policies had lower reported CLABSI rates, but this association was statistically insignificant.

Conclusion: There was a nonsignificant trend in decreasing CLABSI rates as PICUs improved bundle policy compliance. Given that few PICUs reported full compliance with these policies, PICUs increasing their efforts to comply with these policies may help reduce CLABSI rates.

Central line–associated bloodstream infections (CLABSI) are a major source of hospital-acquired infections (HAIs) in intensive care unit (ICU) patients, including pediatric intensive care unit (PICU) patients, and are associated with increased morbidity, mortality, and costs.[1,2] Encouraged by organizations, such as the Institute for Healthcare Improvement,[3] and publications, such as the Pronovost et al study[4] in 2006, ICUs have increasingly sought to prevent CLABSIs through the use of sets of evidence-based practices or care bundles.

Since the adoption of central line (CL) bundle policies and other practices, CLABSI rates among ICUs collectively have fallen nearly 60% in the past decade.[5,6] These aggregate data are heavily skewed toward adult ICUs given their greater number compared with PICUs.[7] There has only been 1 multi-institutional study of the overall trend of CLABSI rates in PICUs in the era of CL bundle practices.[8]

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Single-center studies and multicenter collaborative quality improvement efforts performed in PICUs in the United States have demonstrated that implementation of bundle strategies were associated with a reduction in CLABSI rates.[9] Others have suggested that in the PICU population, maintenance strategies may have a more significant impact on CLABSI rates than insertion strategies,[10-12] whereas others have shown that specific maintenance strategies (eg, chlorhexidine entry scrubs, sponges) were not associated with reduced CLABSI rates.[13] However, little is known about specific prevention practices or the impact of these and other practices in a larger nationwide sample.

Knowing the trend of PICU CLABSI rates, the current extent of CL bundle compliance, and the impact of compliance on rates among a large cohort of U.S. PICUs is necessary to understand what has been accomplished and what can be improved in CLABSI prevention. Therefore, we conducted a multi-institutional longitudinal study of National Healthcare Safety Network (NHSN) hospitals with PICUs to describe their PICU-specific CLABSI rates over time and a cross-sectional study of their adoption of and compliance with specific CLABSI prevention practices. We also investigated the association between these rates and hospital-PICU characteristics, institutional HAI prevention practices, and PICU-specific compliance with bundle elements. We hypothesized that higher compliance with CL bundle practices would be associated with lower PICU CLABSI rates.

METHODS

Study design and study hospitals

In 2011, infection prevention and control (IP&C) departments of nonveteran NHSN hospitals were invited to participate in a study (Prevention of Nosocomial infections and Cost Effectiveness Refined [P-NICER]) to assess the impact of infection prevention processes and state-mandated HAI reporting on ICU HAI rates. The NHSN is the Centers for Disease Control and Prevention's (CDC's) national HAI surveillance system.[14] Participation in the P-NICER NHSN group entailed completion of an online survey (subsequently discussed) and permission for the P-NICER study team to access the hospital's NHSN data.[15] Among other data, this included the number of ICU-specific device-associated infections, the number of device days from time of entry into NHSN (as early as 2006) through mid-2012, and institutional characteristics. Data were reported by hospitals using standard NHSN definitions and methodologies,[16] which are recognized as the gold standard for HAI surveillance.[17,18] Additional detail on this survey and its methodology has been published elsewhere.[19,20]

This current analysis focuses on PICUs and their hospitals among the larger group of NHSN hospitals. At the end of 2011, there were 3,374 nonveteran NHSN hospitals, of which 342 (10%) had a PICU. Characteristics of the participating hospitals and their PICUs were collected through the NHSN, including their geographic region (Northeast, South, Midwest, or West), institution type (general vs freestanding children's hospital), medical school affiliation (yes vs no), unit type (medical-surgical or medical vs cardiothoracic), and number of ICU beds ($\leq$15 vs $>$15). Medical-surgical and medical units were grouped together because there were only 8 medical units. We also evaluated the proportion of hospitals that were located in states that had mandatory reporting of CLABSI rates before December 2011. To determine whether PICU CLABSI data submission was mandatory, pertinent HAI laws (state statutes, administrative regulations, other administrative requirements) were systematically reviewed for all U.S. states and territories.[21]

Survey of infection prevention practices

A psychometrically tested online survey assessing IP&C policies and practices was adapted from previous research.[19,20] Survey respondents were the director or manager of the hospital's IP&C department. The survey inquired if the institution had an electronic surveillance system for tracking HAI, a policy of antibiotic stewardship-restriction, and specific policies and practices related to CL infection control. In addition to investigating policies and practices related to CL insertion in adult ICUs, the survey also asked about PICU-specific policies and practices if the hospital had a PICU. Respondents were asked whether the PICU had written policies for checklist use at CL insertion, along with 5 CL bundle elements (choice of optimal catheter insertion site, chlorhexidine skin disinfection, maximal barrier precautions, monitoring of hand hygiene practices, assessment of daily line necessity). Respondents were also asked to report percent compliance with each written policy during the last period monitored. Compliance was categorized as all of the time (95-100%; full compliance), usually (75%-94%), sometimes (25%-74%), rarely or never ($<$25%), do not know, or no monitoring was performed. We report the aggregate presence of and compliance with these CL policies in the study PICUs.

CLABSI rates and statistical analyses

Mean PICU CLABSI rates per 1,000 CL days were calculated by dividing the summed number of CLABSI events by the summed number of CL device days, multiplied by 1,000. As recommended by the CDC, mean overall rates were weighted by the summed number of CL days to calculate pooled means. As opposed to averaging mean rates across units, pooled means permit more efficient, less biased estimates because they do not ignore unit-level variation of device utilization and avoid potentially overestimating rates by including the number of CL days of those PICUs that had zero infection in the numerator. Pooled mean CLABSI rates are presented with their SDs and 95% confidence intervals.

To illustrate the trend of CLABSI rates between 2006 and mid-2012, we report pooled mean rates by year; 2011 and 2012 data were combined because only 4-6 months of 2012 data were available depending on the unit and because the same hospitals-units participated in both of these periods. A Wald test of composite linear hypotheses was performed to determine if the mean CLABSI rates were equivalent between the different years.

To determine the association between CLABSI rates in 2011 and mid-2012 and institutional characteristics, institutional HAI prevention practices, and PICU-specific compliance with bundle elements as reported in the survey, we used unadjusted negative binomial regression modeling.[22] The sum of CL days was used as the exposure variable. Negative binomial modeling was used because it adjusts variance independently from the mean and is more flexible in regard to overdispersion, as opposed to Poisson modeling. Levels of compliance to the bundle policies and other responses to the survey's compliance questions (do not know, no monitoring, no response) were treated as a categorical independent variable in these unadjusted regression models, with $\geq$95% compliance being the reference. To investigate the association between CLABSI rates and high compliance with multiple bundle policies, we fitted an unadjusted negative binomial regression model with a number of bundle policies for which there was $\geq$95% reported compliance as the categorical independent variable. In this case, $\geq$95% compliance with all 6 policies was the reference. In a sensitivity analysis, we examined the association between CLABSI rates in 2011 and mid-2012 and PICU-specific compliance with bundle elements, excluding units whose reported compliance rates were missing or the respondent indicated do not know.