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Impact of Postnatal Age on Neonatal Intensive Care Unit Bloodstream Infection Reporting

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INTRODUCTION

Bloodstream infections are a significant cause of morbidity and mortality in the neonatal intensive care unit (NICU).[1] Neonates with very low birth weight (VLBW) (≤1500 grams) have higher infection rates than neonates with birth weight >1500 grams. As a result, the Centers for Disease Control and Prevention National Healthcare Safety Network (NHSN) and other national organizations risk adjust certain NICU quality measures, including central line-associated blood stream infections (CLABSI), based on birth weight categories.[1,2]

Recently, hospital-onset bacteremia (HOB) has emerged as an alternative quality measure to the more cumbersome CLABSI, but risk adjustment strategies for the new HOB metric have not been explored in the NICU population.[3] In recent years, advances in care have led to better outcomes for both extremely premature infants and term neonates with formerly lethal conditions; altering NICU population demographics, improved survival, and prolonging NICU stays.[4–6] The existing birth weight-based risk stratification approach assumes that

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NICU patients have a constant bloodstream infection risk irrespective of the duration of their admission. We hypothesized that HOB risk changes over time, such that after a certain postnatal age, all infants in the NICU may have the same risk of bloodstream infection. Our objective was to determine whether the risk of HOB in neonates of different birth weight categories varies by postnatal age to inform whether accounting for postnatal age will improve HOB as a future quality measure.

METHODS

We performed a multicenter retrospective cohort study of neonates admitted to three NICUs within the Johns Hopkins Health System (the level IV Johns Hopkins Children's Center [JHCC] NICU, the level III Howard County General Hospital [HCGH] NICU and the level III Johns Hopkins Bayview Medical Center [JHBMC] NICU) between March 1, 2016, and June 20, 2020 (Table 1). The primary outcome was HOB, defined as a positive blood culture collected more than three days after admission to the NICU. The primary exposure was postnatal age in days. We analyzed the first HOB event per NICU admission. Observation time started from the fourth day of the NICU admission, and continued until the first of NICU discharge, or the date of the first positive blood culture collection. Exclusion criteria included missing birth weight and length of NICU stay less than four days. Data were obtained via review of the electronic medical record.

A Poisson regression model was used to estimate and compare the incidence rate of HOB, expressed as HOBs per 1000 NICU-days, for neonates with birth weight ≤1500 versus >1500 grams, separately by two-week intervals of postnatal age. Data were analyzed using Stata 15 (College Station, TX: StataCorp LLC) and reported as proportions, medians with interquartile range (IQR), and incidence rates (IR) and IR ratios (IRR). The Johns Hopkins Institutional Review Board approved this study with a waiver of informed consent.

RESULTS

During the study period, there were 5,879 neonates admitted to the NICU accounting for 6,422 NICU admissions. After excluding 2,073 admissions due to length of stay <4 days (n=1,912) or missing birth weight data (n=161), the analysis included 4,349 eligible admissions from 4,026 neonates with 91,240 NICU-days. Among the 4,026 neonates, 1,806 (45%) were female and 837 (21%) weighed ≤1500g at birth. Among neonates ≤1500g at birth, median birth weight was 1020g IQR 770 – 1280) and median length of NICU stay was 43 days (range 4 – 259, IQR 23 – 74). Among neonates >1500g at birth, median birth weight was 2650g (IQR 2060 – 3310) and median length of NICU stay was 12 days (range 4 – 212, IQR 7 – 21).

There were a total of 83 HOB events (IR 0.91 HOBs/1000 NICU-days) with 58 (70%), 9 (11%) and 16 (19%) occurring at JHCC, HCGH, and JHBMC, respectively. Of the 83 HOB events, 63 (76%) occurred in neonates ≤1500g at birth. The overall IR of HOB was 1.38 vs. 0.44 per 1000 NICU-days for neonates weighing ≤1500g versus >1500g at birth, respectively (IRR 3.13, 95% CI: 1.89 – 5.17). The HOB IRR declined rapidly over time (i.e. postnatal age), such that after 4 weeks of age, the HOB incidence rates did not differ

statistically across the two birth weight groups (Table 2). All HOB events beyond 6 weeks of age occurred at the JHCC level IV NICU, where the two birth weight groups showed similar incidence rates (IRR 1.04, 95% CI 0.39 – 2.78) (Supplemental table).

DISCUSSION

We found that the relative risk of HOB in VLBW neonates was similar to non-VLBW neonates by approximately six weeks of postnatal age. NICUs are unique in that patients have long lengths of stay and changing severity of illness over time. The results of this study suggest that accounting for postnatal age in additional to birthweight may improve HOB reporting for hospital comparisons.

In neonates and infants, bloodstream infections can have devastating short- and long-term consequences and are tracked by national and international organizations as important healthcare quality measures.[1,2,7–9] Transparent public reporting of outcomes can lead to enhanced quality of care as organizations strive to improve. However, reporting healthcare quality outcomes is time-consuming. Given readily available data on bloodstream infections, HOB has been proposed as an alternative quality measure to the time-intensive CLABSI event.[3] This study suggests that HOB should be risk adjusted if used to compare NICU performance for bloodstream infection rates.

The primary limitations were the small sample size and exclusion of repeat HOB events (although only two neonates had repeat events >14 days following their analyzed event).[2] Our findings suggest HOB incidence may correlate with NICU level, which may be informative for risk-adjustment if this distinction is found across other nationwide NICUs. Future analyses using larger multicenter datasets should examine distinctions between level III and level IV, the impact of repeat events, and the robustness of these findings across additional birth weight groups.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1.

Neonatal intensive care unit characteristics

	JHH	HCGH	JHBMC
Number of Beds	42	25	25
Level	IV	III	III
Admissions per year, average	717	401	319
Proportion of admissions with birth weight <1500g, %	21.7	9.9	17.1
Median length of stay, days (range)	13 (1–336)	6 (1–123)	9 (1–172)

Table 2:

Hospital-onset Bacteremia (HOB) Incidence per 1000 NICU-days by Birth weight Group Stratified into Two-Week Time Intervals by Postnatal Age

		Postnatal Age			
		Weeks 1–2^	**Weeks 3–4**	**Weeks 5–6**	**>Week 6 ^^**
≤1500g	No. of admissions	768	722	608	604
	No. of HOBs	29	12	6	16
	NICU-days	7814	8884	7293	21781
	Rate /1000 NICU-days (95% CI)	3.71 (2.36 – 5.06)	1.35 (0.59 – 2.11)	0.82 (0.16 – 1.48)	0.73 (0.37 – 1.09)
>1500g	No. of admissions	3202	1409	540	254
	No. of HOBs	7	6	2	5
	NICU-days	22627	12377	4820	5644
	Rate /1000 NICU-days (95% CI)	0.31 (0.08 – 0.54)	0.48 (0.10 – 0.87)	0.41 (−0.16 – 0.99)	0.89 (0.11 – 1.66)
Unadjusted IRR (≤1500g relative to >1500g) (95% CI)		12.00 (5.26 – 27.37)	2.79 (1.04 – 7.43)	1.98 (0.40 – 9.82)	0.83 (0.31 – 2.22)

^ At-risk observation time did not include the first three days of life (for inborn infants), or the first three days of an NICU admission (for infants transferred from another unit or facility).

^^ time was censored at one year of postnatal age

NICU: neonatal intensive care unit

IRR: incidence rate ratio