BRIEF REPORT

Recent Trends in Infant Car Seat Tolerance Screening Failure Within a Large Health Care System, 2014–2018

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ABSTRACT

OBJECTIVES: To describe temporal trends in car seat tolerance screening (CSTS) failure within a large hospital system (2014–2018).

METHODS: We conducted a retrospective cohort study using electronic medical record data for infants who underwent a CSTS. Our primary outcome measure was the CSTS failure rate. Covariates included year, CSTS location (well nursery or NICU), gestational age (GA), race, sex, birth weight, CSTS date, and age at CSTS. Associations of covariates with CSTS failure were examined by using χ^2 tests, t tests, analysis of variance, and Wilcoxon rank tests. Multivariable logistic regression was used to determine the adjusted odds of CSTS failure.

RESULTS: Of 4849 infants tested, the failure rate was 8.1% ($n = 394$). Most CSTS occurred in the well nursery (79.5%) and involved late preterm (55.2%) or term infants (23.7%). In bivariate analyses, year, unit location, higher birth weight, younger chronological age at testing, and higher GA were positively associated with CSTS failure ($P < .05$). After stratification by CSTS location, the CSTS failure rate rose in the well nursery but remained stable in the NICU, and use of screening rose among term infants. In the adjusted model, year, GA, and corrected gestational age at CSTS were associated with failure. Each subsequent year was associated with a 19% increase in odds of CSTS failure ($P < .001$).

CONCLUSIONS: We found a higher rate of CSTS failure in the well nursery compared with the NICU, and the difference in failure rates increased over time. Improved understanding of infants at the highest risk of CSTS failure could impact routine screening guidelines.

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The American Academy of Pediatrics recommends that preterm newborns undergo monitoring in a car seat (the car seat tolerance screening [CSTS]) before discharge.[1–3] Published CSTS failure rates range from 4.2% to 83%, although the population of infants undergoing screening and the criteria for failure vary across sites.[4–10] Higher failure rates among infants in the nursery compared with the NICU have been reported.[4,11,12] Other infant characteristics, such as gestational age (GA), race, low birth weight (BW), and sex, have been inconsistently associated with failure.

Although authors of a recent large study described the epidemiology of CSTS across multiple NICUs,[11] to our knowledge no authors of previous large studies have described CSTS failure in both well-newborn and NICU settings or have described trends in failure over time.

Our primary aim for this study was to determine the rate and trends of CSTS failure within a large hospital system. Our secondary aim was to examine infant characteristics that predicted CSTS failure in NICU and nursery populations.

TABLE 1 Demographic and Clinical Factors Associated With Initial CSTS Result

	Passed	Failed	*P*
	n = 4455 (91.9%)	*n* = 394 (8.1%)	
Hospital site, *n* (%)			.673
Community	1994 (92.1)	172 (7.9)	
Academic	2461 (91.7)	222 (8.3)	
Location in hospital, *n* (%)			.001
Well newborn nursery	3519 (91.2)	338 (8.8)	
NICU or SCN	936 (94.4)	56 (5.7)	
Study year, *n* (%)			.012
2014	552 (93.1)	41 (6.9)	
2015	962 (93.5)	67 (6.5)	
2016	949 (92.5)	77 (7.5)	
2017	1001 (91.3)	95 (8.7)	
2018	991 (89.7)	114 (10.3)	
Sex, *n* (%)			.675
Female	2088 (91.7)	189 (8.3)	
Male	2367 (92.0)	205 (8.0)	
Race or ethnicity, *n* (%)			.095
White	2417 (91.4)	227 (8.6)	
African American	989 (93.7)	66 (6.3)	
Asian American	203 (91.0)	20 (9.0)	
Other or unknown	846 (91.3)	81 (8.7)	
GA category, *n* (%)			.027
EPT	963 (93.9)	63 (6.1)	
LPT	2439 (91.2)	236 (8.8)	
Term	1053 (91.7)	95 (8.3)	
GA, wk, mean ± SD	34.8 ± 3.2	35.1 ± 2.9	.049
CGA, wk, mean ± SD	37.2 ± 3.3	36.9 ± 4.6	.047
BW, kg, mean ± SD	2.4 ± 0.7	2.5 ± 0.7	.004
LOS, d, median (IQR)	5.7 (3.0–18.3)	4.3 (3.1–11.7)	.043

EPT is categorized as <34 wk GA, LPT is categorized as <37 wk GA, and term is categorized as ≥37 wk GA. IQR, interquartile range; SCN, special care nursery.

METHODS

Study Population

We conducted a retrospective review of electronic medical record (EMR) data at 2 large hospitals in a major health care system. Both hospitals (1 academic, 1 community) used the same EMR (Epic) to log CSTS results. Inclusion criteria were infants who underwent a CSTS from April 5, 2014 (when Epic was initiated), to December 31, 2018, within well-newborn nurseries (nursery) and level II or higher nurseries (NICU). No infants were excluded. Approval was granted by the institutional review board.

CSTS Procedures

Infants <35 weeks' gestation were admitted to the NICU. Otherwise well infants ≥35 weeks' gestation were admitted to the nursery. Both units screened infants born <37 weeks' GA or <2.27 kg. Additional infants were screened at physician discretion. CSTSs were conducted by using Philips IntelliVue MP50 monitors (10-second averaging times). Infants underwent 90 minutes of cardiorespiratory monitoring under observation by a trained registered nurse. Failure criteria were bradycardia (heart rate <80 beats per minute) sustained for ≥10 seconds, apnea (>20 seconds), or desaturation <92% sustained for ≥10 seconds (University of North Carolina at Chapel Hill Nursing Policy Committee, unpublished). A certified car seat technician was available for questions regarding proper infant positioning. Infants who failed underwent repeat testing no sooner than 12 hours after previous screen and underwent additional workup per physician recommendations. Criteria remained the same during the study period.

Outcome

The primary outcome was the rate of initial CSTS failure each study year. CSTS results were dichotomized (pass or fail).

Covariables

Covariates included study year, sex, race and/or ethnicity (white, African American, Asian American, or other or unknown), GA, GA category (early preterm [EPT] [<34 weeks' gestation], late preterm [LPT] [≥34 and <37 weeks' gestation], and term [≥37 weeks' gestation]), BW, corrected gestational age (CGA), length of stay (LOS), hospital site, and location of admission (NICU or nursery). Dates of birth and CSTS results were extracted.

Statistical Methods

Descriptive statistics were used to examine cohort characteristics. We compared infant characteristics by CSTS result (pass or fail) using χ^2 tests, Fisher's exact tests, *t* tests, and Wilcoxon rank tests as appropriate for categorical, continuous, and nonparametric variables. We used analysis of variance with Bonferroni correction (parametric) and Kruskal-Wallis tests (nonparametric) to examine differences in continuous outcomes between multiple groups. Logistic regression models were used to determine clinical characteristics associated with CSTS failure. Characteristics were chosen a priori, and models were reduced by using backward elimination. $P < .05$ was considered significant. StataIC version 15 (Stata Corp, College Station, TX) was used for analysis.

RESULTS

Demographics

Of 4849 infants, 8.1% failed an initial CSTS ($n = 394$; Table 1). Overall, 55.2% of infants were LPT, whereas 23.7% were term. Boys made up 53% of the cohort, and the mean BW was 2.41 ± 0.72 kg. The majority of infants were admitted to the nursery (79.5%). Infants were white (54.5%), African American (21.8%), and Asian American (4.6%).

Failure Trends

CSTS failure increased from 6.9% to 10.3% during the study ($P < .05$; Table 1). After stratifying by CSTS location, 5.7% of infants in the NICU failed, compared with 8.8% in the nursery ($P < .001$). The increasing failure rate only occurred in the nursery (Table 2). The absolute number of CSTSs performed on term and LPT infants increased in the nursery, where they made up 24.3% to 28.1% and 52.1% to 53.6% of those tested from 2014 to 2018, respectively ($P < .001$). There was a reciprocal decrease in the percentage of those screened who were EPT infants; however, the absolute number of tests among EPT infants remained stable.

Characteristics Associated With Failure

More LPT and term infants than EPT infants failed (8.8%, 8.3%, and 6.1%, respectively; $P = .027$; Table 1). The failure rate was lower among African American (6.3%) infants compared with white (8.6%) and Asian American (9.0%) infants, but it was not statistically significant ($P = .095$). Higher GA and BW, but lower CGA (36.9 vs 37.2 weeks), were associated with failure ($P < .05$). On the subgroup analysis, the association between higher GA and failure was only present among LPT infants (35.4 vs 35.3 weeks; $P < .01$). The mean CGA of infants who failed was higher in the NICU compared with the nursery (39.2 vs 36.5 weeks; $P < .001$).

Multivariable Models

We created separate multivariable models for infants in the nursery and NICU (Table 3). Multivariable logistic regression models included study year, sex, race, GA, BW, and CGA. In the fully adjusted model, within the nursery, study year, GA, and CGA at time of CSTS were associated with CSTS failure (Table 3). Every additional study year was associated with a 19% increase in odds of

TABLE 2 Characteristics of Infants by CSTS Result and Location of Test Within Hospital

	Well-Newborn Nursery ($n = 3857$)			NICU ($n = 992$)		
	Passed	Failed	P	Passed	Failed	P
	$n = 3519$ (91.2%)	$n = 338$ (8.8%)		$n = 936$ (94.4%)	$n = 56$ (5.7%)	
Hospital site, *n* (%)			.176			.922
Community	1822 (91.8)	162 (8.2)		172 (94.5)	10 (5.5)	
Academic	1697 (90.6)	176 (9.4)		764 (94.3)	46 (5.7)	
Study year, *n* (%)			.012			.475
2014	404 (93.5)	28 (6.5)		148 (91.9)	13 (8.1)	
2015	738 (93.0)	56 (7.1)		224 (95.3)	11 (4.7)	
2016	754 (91.7)	68 (8.3)		195 (95.6)	9 (4.4)	
2017	824 (90.6)	86 (9.5)		177 (95.2)	9 (4.8)	
2018	799 (88.9)	100 (11.1)		192 (93.2)	14 (6.8)	
Sex, *n* (%)			.379			.236
Female	1661 (90.8)	168 (9.2)		427 (95.3)	21 (4.7)	
Male	1858 (91.6)	170 (8.4)		509 (93.6)	35 (6.4)	
Race or ethnicity, *n* (%)			.057			.240
White	1964 (91.1)	193 (9.0)		453 (93.0)	34 (7.0)	
African American	763 (93.4)	54 (6.6)		226 (95.0)	12 (5.0)	
Asian American	182 (90.1)	20 (9.9)		21 (100)	0 (0.0)	
Other or unknown	610 (89.6)	71 (10.4)		236 (96.0)	10 (4.1)	
GA, wk, mean ± SD	35.1 ± 2.6	35.5 ± 2.2	.003	33.6 ± 4.6	32.6 ± 4.8	.119
CGA, wk, mean ± SD	36.7 ± 2.4	36.5 ± 1.5	.059	39.3 ± 5.2	39.2 ± 11.7	.904
BW, kg, mean ± SD	2.4 ± 0.6	2.6 ± 0.6	<.001	2.2 ± 1.0	2.2 ± 1.2	.696
LOS, d, median (IQR)	4.1 (2.8–11.7)	3.9 (3.0–7.7)	.724	22.7 (10.2–56.1)	28.9 (10.0–65.9)	.647

IQR, interquartile range.

TABLE 3 Unadjusted and Adjusted Odds Ratios of Factors Associated With CSTS Failure

	Unadjusted OR (95% CI)	*P*	Adjusted OR (95% CI)	*P*
Well-newborn nursery				
Study year	1.17 (1.07–1.27)	<.001	1.19 (1.09–1.30)	<.001
Female sex	1.11 (0.88–1.38)	.379	1.14 (0.90–1.43)	.269
Race or ethnicity				
White	Reference	—	Reference	—
African American	0.72 (0.53–0.98)	.040	0.76 (0.55–1.04)	.086
Asian American	1.12 (0.69–1.82)	.651	1.11 (0.68–1.81)	.681
Other or unknown	1.18 (0.89–1.58)	.247	1.13 (0.84–1.52)	.401
GA, wk	1.08 (1.03–1.13)	.003	1.08 (1.00–1.18)	.049
BW, kg	1.37 (1.14–1.64)	.001	1.21 (0.95–1.54)	.123
CGA, wk	0.95 (0.90–1.01)	.111	0.89 (0.82–0.97)	.008
NICU				
Study year	0.98 (0.80–1.19)	.817	1.01 (0.82–1.23)	.950
Female sex	0.72 (0.41–1.25)	.237	0.72 (0.41–1.28)	.267
Race or ethnicity				
White	Reference	—	Reference	—
African American	0.71 (0.36–1.39)	—	0.70 (0.35–1.41)	.320
Asian American[a]	—	—	—	—
Other or unknown	0.56 (0.05–0.11)	.121	0.63 (0.30–1.30)	.210
GA, wk	0.96 (0.90–1.01)	.120	0.88 (0.77–1.00)	.051
BW, kg	0.948 (0.72–1.24)	.696	1.53 (0.85–2.76)	.158
CGA, wk	1.00 (0.95–1.05)	.904	1.00 (0.95–1.06)	.860

CI, confidence interval; OR, odds ratio; —, not applicable.
[a] Asian American infants were not included in the NICU model because no Asian American infants failed the CSTS.

CSTS failure ($P < .001$). For each week of GA, odds of CSTS failure increased by 8%. In the fully adjusted model for the NICU, no significant associations with CSTS failure were identified.

DISCUSSION

To our knowledge, this is the first study in which CSTS failures are examined over time. The rise in CSTS failures in the nursery was likely multifactorial. A review of CSTS protocols during this period revealed no changes in screening guidelines, equipment, or criteria for failure. However, we identified differences over time in characteristics of infants undergoing CSTS, such as a significantly higher absolute number and proportion of both term and LPT infants undergoing screening each study year. Term infants who fail the CSTS are of substantial clinical importance given that there are no specific conditions or weight cutoffs for which CSTS is currently recommended other than prematurity. As providers become more familiar with the CSTS, they may screen at-risk infants with conditions such as low BW, Down syndrome, neuromuscular disorders, craniofacial abnormalities, and congenital heart disease (as referenced in the American Academy of Pediatrics guidelines) more often, which are important areas for future research.[2]

Similar to previous studies, CSTS failure was more common in the nursery than the NICU.[4,11,12] Possible explanations for higher failure rates in the nursery include the following: (1) infants in the NICU undergo more cardiorespiratory evaluation, potentially leading to identification of apnea and bradycardia before CSTS and (2) well-nursery discharges often occur between 48 and 96 hours, so providers may perform the CSTS at an earlier CGA, when infants are less mature. Supporting this explanation, our data reveal that compared with infants in the nursery, infants in NICU had a higher CGA at the CSTS and more frequently passed the screen. A greater postnatal age, perhaps as a result of a longer interval for postnatal maturation, is associated with passing the CSTS.[4,13] Somewhat counterintuitively, infants with an older GA and higher BW were more likely to fail in the nursery. Authors of some previous studies reported this association, whereas others found no association.[1,4,14–16]

For infants screened in the NICU, it is possible that characteristics not examined in this study may better predict CSTS failure. Factors shown to be associated with CSTS failure among infants screened in the NICU (eg, caffeine, requiring continuous positive airway pressure, maternal cesarean delivery, surfactant use, or antacid use)[11] were not examined in this study.

Despite widespread CSTS implementation, its benefits remain unclear. One study revealed that infants who failed the CSTS had lower adjusted odds of readmission by 30 days.[11] Although CSTS is routine in many US hospitals, the Canadian Pediatric Society does not recommend routine screening, citing lack of evidence to support improved outcomes and concern for potential risk.[17–19] One potential risk is increased cost given that each test requires a minimum of 90 minutes of direct staff and/or nursing observation.[2,19] Other potential risks include maternal-infant separation, caregiver stress, and false reassurance among caregivers.[17]

Limitations of this study include the inability to examine all factors associated with CSTS results, such as underlying medical conditions or indication(s) for which providers chose to screen infants. Also, we did not examine reasons for failure or transfers between the NICU and nursery and their association with failure, which are important areas for future study. Although 2 major sites were included, the data represent only 1 health care system, and only partial EMR data were available for 2014 because of EMR implementation that year. Lack of CSTS outcome data limits our ability to assess the risk/benefit ratio.

CONCLUSIONS

The CSTS failure rates differed in nursery and NICU settings, and failures increased in the well nursery. Authors of future studies should examine if these trends in CSTS failure exist across other hospitals, should further elucidate predictors of failure, and should examine longer-term outcomes. Improved identification of infants at highest risk of CSTS failure may impact routine screening guidelines.

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