Journal of Perinatology (2017) 37, 88–90

www.nature.com/jp

ORIGINAL ARTICLE

Clinically significant cardiopulmonary events and the effect of definition standardization on apnea of prematurity management

MBF Powell[1], CR Ahlers-Schmidt[1], M Engel[1] and BT Bloom[2]

OBJECTIVE: To define the impact of care standardization on caffeine and cardiorespiratory monitoring at neonatal intensive care unit (NICU) discharge.

STUDY DESIGN: Electronic records were abstracted for infants aged 24–36 weeks gestation with birth weights appropriate for gestational age. Infants who died, transferred prior to discharge, had major pulmonary anomalies, required a home monitor for mechanical ventilation or had a family history of sudden infant death syndrome were excluded. Data and records were used to indicate when the new definition of clinically significant cardiopulmonary events (CSCPEs) and concurrent education was implemented. Preimplementation and postimplementation cohorts were compared.

RESULTS: Incidence fell from 74% diagnosed with apnea of prematurity at baseline to 49% diagnosed with CSCPE postimplementation ($P < 0.001$). Infants discharged on caffeine reduced from 17% to 5% ($P < 0.001$), and home monitor use also fell from 54% to 16% ($P < 0.001$).

CONCLUSION: Standardizing definitions and treatments reduced the use of caffeine and cardiorespiratory monitors upon NICU dismissal.

Journal of Perinatology (2017) **37,** 88–90; doi:10.1038/jp.2016.167; published online 29 September 2016

INTRODUCTION

Respiratory pausing is common in preterm infants. The clinical significance increases when pauses are prolonged or associated with changes in perfusion, heart rate or oxygen desaturation.

Apnea of prematurity (AOP) has been defined as a pause in breathing for either >20 s or >10 s if accompanied by bradycardia, oxygen desaturation or cyanosis in infants <37 weeks gestational age.[1] The primary etiology of AOP is the immaturity of the neurological and respiratory systems,[2] and frequency of AOP is inversely related to gestational age.[3] Mild and infrequent AOP events have no long-term consequence; however, increasing number of days of apnea has been shown to be associated with poorer neurological outcomes.[4]

Effective treatments for AOP include the use of continuous positive airway pressure and caffeine. Variations in threshold for starting and stopping these treatments exist, with frequency and severity of individual spells influencing treatment decisions.[2,5–8] These thresholds are complicated by the inability to define the actual duration of apnea by the nursing staff.[9]

Multiple factors, including monitoring, diagnosis and treatment, result in center-to-center variability of in-hospital treatment with caffeine and use of home monitors at discharge.[2,5–8] Standardization is one approach in health-care delivery systems to increase patient safety and reduce variation.[10] In recognition of our center's high rate of discharging infants on apnea monitors, we introduced standardized definitions for defining respiratory pauses along with concomitant training.

This study was designed to examine the effects of this standardized definition and clinical education on AOP management. We hypothesized that these changes would reduce the frequency of AOP diagnosis, the use of caffeine and home apnea monitoring at discharge.

MATERIALS AND METHODS

In early 2014, after finding our center was above the 75th percentile in the use of home monitoring, we joined a Vermont Oxford Network Intensive Care Neonatal Collaborative (NICQ 7) to reach a pragmatic consensus on the definition of significant events and to standardize documentation and management guidelines.[11] This center's institutional review board determined that the evaluation of this process was exempt from review.

The term clinically significant cardiopulmonary event (CSCPE) was introduced, and education for physicians, nurse practitioners, nurses and respiratory therapists was provided to reduce the variation in diagnosis. CSCPE was defined as 20 s of no breathing or 10 s of no breathing concurrent with either a heart rate <80 beats per minute or oxygen desaturation >85%.[9,11] Events were not counted if they occurred during an intervention, such as suctioning, nasogastric tube placement, a feeding or any other extrinsic manipulation of the infant that may inherently cause a pause in breathing. This definition was used for all neonatal intensive care unit (NICU) patients throughout the course of treatment. A treatment guideline for when to start and stop caffeine was introduced. The existing protocol dictated that infants with persistent apnea who were otherwise ready for discharge would be sent home on a monitor with parents' consent. For this project, home-monitoring decision-making was left unchanged.

This was a retrospective evaluation of existing clinical data from the nursing and medical electronic health-care records of infants who were

[1]Department of Pediatrics, University of Kansas School of Medicine-Wichita, Wichita, KS, USA and [2]Department of Neonatology, Wichita Medical Research and Education Foundation, Wichita, KS, USA. Correspondence: Dr BT Bloom, Department of Neonatology, Wichita Medical Research and Education Foundation, 550N Hillside, Wichita, KS 67214, USA.
E-mail: barrybloom@aol.com
Received 10 June 2016; revised 22 August 2016; accepted 30 August 2016; published online 29 September 2016

provided clinical care in a 72-bed, Level IIIC NICU at Wesley Medical Center in Wichita, KS, USA.

Infants in this study were 24–36 completed weeks of gestation at birth with weights appropriate for gestational age (by the Fenton Maturational Assessment of Gestational Age chart). Infants were excluded if they died or were transferred prior to discharge, were given caffeine for a reason other than AOP or CSCPE, had major pulmonary anomalies, required a home monitor for mechanical ventilation or oxygen at discharge or had a family history of sudden infant death syndrome.

All study data were de-identified prior to analysis. Descriptive statistics were tabulated, utilizing frequencies for categorical variables and medians and interquartile ranges for continuous variables. Mann–Whitney *U*, Kruskal–Wallis and Chi-squared tests were used to compare characteristics between the baseline and postimplementation cohorts. Non-parametric statistics were used given the skewed distributions of both age and birth weight.

RESULTS

The proportion of home monitoring at dismissal for each group of 50 dismissals was tracked as a run chart (Figure 1). Defined by this run chart, infants dismissed from 1 January 2012 to 31 December 2013 formed the baseline group, from 1 January 2014 and 31 August 2014 was the implementation period and those from 1 September 2014 to 31 July 2015 formed the postimplementation group.

A total of 1312 cases matched inclusion/exclusion criteria. Of these, 260 were seen during the implementation period and were not analyzed. Between the baseline and postimplementation cohorts, there was a significant difference in gestational age and birth weight but no difference in gender (Table 1).

AOP was noted in 74% of infants in the baseline group, while CSCPE was documented in 49% of infants in the postimplementation group ($P < 0.001$). The incidence of treatments at discharge decreased. In the baseline group, 17% were discharged with caffeine and 5% in the postimplementation group ($P < 0.001$). Home monitor use also fell from 54% in the baseline group to 16% in the postimplementation group ($P < 0.001$).

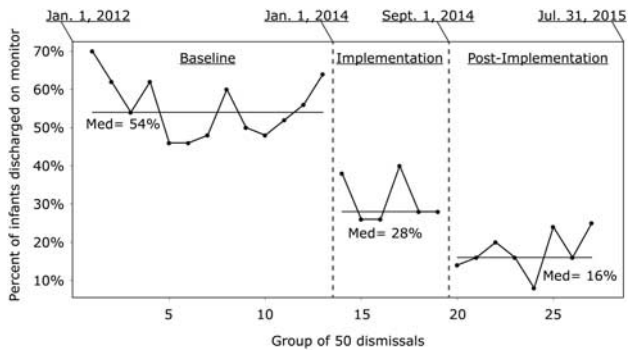

Figure 1. Run chart of infants discharged on apnea monitor for every 50 dismissals.

Given that birth weight and gestational age were different, *post-hoc* subgroup analysis was performed by traditional weight categories for normal birth weight (>2500 g), low birth weight (1501–2500 g) and very low birth weight (<1501 g) infants (Table 2). Although each outcome was inversely related to increases in birth weight, the implementation of the new definition always resulted in a reduction. In multivariate modeling (not reported), the interaction between birth weight and implementation group was not statistically significant.

DISCUSSION

There was a distinct decrease in the incidence of diagnosis from AOP to CSCPE as well as the use of caffeine and home apnea monitors at the time of discharge after implementation of these changes. This study reinforces previous work suggesting that such standardization can be effectively introduced in an NICU environment[9] and shows sustained changes over the 11 months following implementation.

One consideration here is that the statistically significant difference in birth weights and gestational age between the baseline and postimplementation groups may lead to an overestimation of the benefits of these changes. However, this analysis supports that there was a beneficial impact of diagnosis and treatments at discharge across all subgroups.

This study's generalizability is limited in that this retrospective study was performed in one NICU setting. The reason for the

Table 2. Intervention impact stratified by birthweight[a]

	Baseline (AOP)	*Postimplementation (CSCPE)*	*Reduction*
Diagnosis[b]			
VLBW, *n* (%)	145 (100)	54 (95)	5%
LBW, *n* (%)	298 (74)	108 (48)	35%
NBW, *n* (%)	65 (47)	16 (19)	59%
Caffeine at discharge			
VLBW, *n* (%)	39 (27)	8 (14)	48%
LBW, *n* (%)	76 (19)	8 (4)	81%
NBW, *n* (%)	5 (4)	1 (1)	67%
Apnea monitor at discharge			
VLBW, *n* (%)	102 (70)	20 (35)	50%
LBW, *n* (%)	231 (57)	35 (16)	73%
NBW, *n* (%)	40 (29)	5 (6)	79%

Abbreviations: AOP, apnea of prematurity; CSCPE, clinically significant cardiopulmonary event; LBW, low birth weight; NBW, normal birth weight; VLBW, very low birth weight. [a]VLBW: <1500 g, LBW: 1500–2500 g, NBW: >2500 g. [b]The definitions of AOP in the baseline group and CSCPEs in the postimplementation group differed as described in the text.

Table 1. Characteristics of participants in the baseline and postimplementation cohorts

Characteristics	*Baseline (n = 687)*	*Postimplementation (n = 365)*	P-*value*
Birth weight (g), median (IQR)	2018 (1584–2415)	2144 (1701–2447)	0.018
Gestational age (days), median (IQR)	236 (220–243)	238 (223–245)	0.048
Female, *n* (%)	308 (45)	171 (47)	0.532
Diagnosis[a], *n* (%)	508 (74)	178 (49)	<0.001
Home apnea monitor, *n* (%)	373 (54)	60 (16)	<0.001
Caffeine at discharge, *n* (%)	120 (17)	17 (5)	<0.001

Abbreviation: IQR, interquartile range. [a]The definitions of apnea of prematurity in the baseline group and clinically significant cardiopulmonary events in the postimplementation group differed as described in the text.

implementation of the CSCPE definition in the first place was because of this center's high incidence of infants discharged on a home apnea monitor. The impact of implementing this standardized definition in a NICU where this rate is already low would likely have less of an impact. There are also some NICU centers that do not send babies home if they still require monitoring for AOP and therefore infants in these settings would never be discharged with an apnea monitor. Nonetheless, there was a significant decrease in the incidence of diagnosis after implementing CSCPE in this study.

CONCLUSION

Standardizing definitions, assessments and treatment reduced the use of caffeine and home apnea monitors upon NICU dismissal. Future management teams should consider adopting these steps.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGEMENTS

We thank Jared Shaw, clinical systems analyst, for his assistance in accessing the data used in this manuscript. We also thank the team who led the implementation of these changes and the staff of the Neonatal Special Nurseries who initiated these changes and adapted their practices to the benefit of our patients. This work was funded by a grant from the Wichita Medical Research and Education Foundation.

REFERENCES

1 National Institutes of Health Consensus Development Conference on Infantile Apnea and Home Monitoring, Sept 29 to Oct 1, 1986. *Pediatrics* 1987; **79**(2): 292–299.
2 Stokowski LA. A primer on apnea of prematurity. *Adv Neonatal Care* 2005; **5**(3): 155–170; quiz 171–174.
3 Daily WJ, Klaus M, Meyer HB. Apnea in premature infants: monitoring, incidence, heart rate changes, and an effect of environmental temperature. *Pediatrics* 1969; **43**(4): 510–518.
4 Janvier A, Khairy M, Kokkotis A, Cormier C, Messmer D, Barrington KJ. Apnea is associated with neurodevelopmental impairment in very low birth weight infants. *J Perinatol* 2004; **24**(12): 763–768.
5 Barrington K, Finer N. The natural history of the appearance of apnea of prematurity. *Pediatr Res* 1991; **29**(4 Pt 1): 372–375.
6 Finer NN, Higgins R, Kattwinkel J, Martin RJ. Summary proceedings from the apnea-of-prematurity group. *Pediatrics* 2006; **117**(3 Pt 2): S47–S51.
7 Miller HC, Behrle FC, Smull NW. Severe apnea and irregular respiratory rhythms among premature infants; a clinical and laboratory study. *Pediatrics* 1959; **23**(4): 676–685.
8 Miller MJ, Martin RJ. Apnea of prematurity. *Clin Perinatol* 1992; **19**(4): 789–808.
9 Butler TJ, Firestone KS, Grow JL, Kantak AD. Standardizing documentation and the clinical approach to apnea of prematurity reduces length of stay, improves staff satisfaction, and decreases hospital cost. *Jt Comm J Qual Patient Saf* 2014; **40**(6): 263–269.
10 Hasibeder WR. Does standardization of critical care work? *Curr Opin Crit Care* 2010; **16**(5): 493–498.
11 Vermont Oxford Network. Past NICQ Collaboratives (cited 18 May 2015). Available from https://public.vtoxford.org/quality-education/quality-improvement-collaboratives/nicq-past-collaboratives.