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Original Article

Outcomes of extremely low birth weight infants in the NICU after initiation of a two-team care model

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ABSTRACT

Neonatal nurse practitioners (NNP) have an increasing and continuous presence in most neonatal intensive care units (NICUs); a presence which has at times been perceived as at odds with the training and development of pediatric residents and neonatal fellows. This is a single-center cohort study of infants born at ≤1000 g and ≤28 weeks of gestation cared for by either a team consisting of residents and a fellow (R/F) or consisting of NNPs (NP). Groups were compared by Student's *t*-test or chi-square, and associations estimated by logistic regression. There were no differences in primary outcomes between the teams except for a lower incidence of severe retinopathy of prematurity (ROP) in babies on the R/F team compared to the NNP team. In this first post-duty hours cohort, clinical outcomes between the teams were similar. These data suggest that either model can be safely utilized within a level 3 NICU.

1. Introduction

There are currently over 3,000 neonatal nurse practitioners (NNPs) licensed to practice in the United States (AANP, 2018). Although NNPs have routinely cared for infants in the neonatal intensive care unit (NICU) since the 1980's, few studies have evaluated patient outcomes under different NICU care team models. Newly graduated NNPs have been reported to be similar to second year pediatric residents in their knowledge, clinical skills and problem-solving (Mitchell et al., 1991). Health care delivered by NNPs has been reported to result in high patient satisfaction and communication (Brown and Grimes, 1995; Kinder, 2016); however other studies evaluating care by NNPs and pediatric residents showed no differences in outcomes (Mitchell-DiCenso et al., 1996; Karlowicz and McMurray, 2000).

In 2011, our NICU leadership started a two-team model, in part to support the need for resident and fellow experience in caring for extremely low birth weight (ELBW) infants. The two teams were made up of either NNPs or residents and a neonatology fellow (R/F). All new admissions were assigned to teams by the charge nurses based on alternating admission days (2:1), with occasional modifications to balance numbers and acuity. This method of team assignment provided a unique, unbiased distribution of patients to providers with different levels of training and management styles.

Within our NICU, there has historically been an anecdotal increase in nursing confidence in NNPs over residents, which tends to be intensified in the most complex clinical care, as occurs during the care of extremely low birth weight (ELBW) babies. The lack of NICU experience that is inherent in residents and other learners is magnified when compared to the NNPs, whose care model is founded in "years spent in clinical practice … [resulting in] a valuable and unique perspective for professional functioning at a senior level" (Smith and Hall, 2011). The perceived disparity in care has been exacerbated by the institution of duty hour regulations in pediatric residencies in 2003, reducing the duration of clinical time that residents and fellows are able to be present in the NICU during their rotations. Although the duty hours changes do not seem to have negatively impacted the education that residents receive while they are rotating in the NICU (DeLaroche et al., 2014), the changes have resulted in increased patient handoffs and reduced continuity of patient care (Desai et al., 2013).

One of the greatest perceived differences between residents and nurse practitioners in providing clinical care to ELBW infants is the comfort level with newer and more advanced modes of respiratory support. This gap in comfort and experience could result in the NNP providers utilizing advance respiratory support such as high-frequency jet ventilation, non-invasive positive pressure ventilation (NIPPV), or neurally-adjusted ventilatory assist (NAVA) more frequently. We sought to evaluate if differences exist in the utilization of different respiratory modalities in ELBW infants between the two health care delivery team

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structures within our NICU, and to assess if these differences were associated with changes in infant outcomes. We hypothesized that there would be no difference in utilization of respiratory modalities or outcomes between the two patient care models.

2. Methods

This single-center retrospective cohort study was approved by the University of Washington IRB committee. ELBW infants (birth weight ≤1000 g) born at ≤28 weeks gestational age (GA) between January 2011 and December 2015 were included in the study. Exclusion criteria included death before 48 h age or infants transferred in after one week of age.

Using the electronic health record, we collected demographic data including sex, GA, birth weight, race, administration of prenatal steroids, 5-min Apgar score, and history of surfactant administration, as well as the need for and duration on various respiratory modalities and duration of time on oxygen. The outcomes that were recorded included length of stay and transfer type (i.e. acute or convalescent) and clinical disease outcomes or co-morbidities (BPD, patent ductus arteriosus (PDA), necrotizing enterocolitis (NEC), retinopathy of prematurity (ROP), grade 3–4 intraventricular hemorrhage (IVH), culture-positive sepsis, pneumothorax, discharge on oxygen, and death). For BPD grading, the NIH definition was used(Jobe and Bancalari, 2001). To diagnose BPD, infants must have an ongoing requirement for supplemental oxygen for 28 days, and then at 36 weeks corrected gestational age, infants are categorized into mild if on room air, moderate if on oxygen support without need for positive pressure and at an $FiO_2 < 0.3$, or severe if requiring positive pressure and/or $FiO_2 \geq 0.3$. Positive pressure was defined in this study as ≥ 2 LPM of high-flow nasal cannula or any amount of nasal continuous positive airway pressure (nCPAP) or NIPPV/NAVA. During the study period, our NICU started utilizing non-invasive NAVA however, we were unable to adequately separate the two modalities using the medical record, so grouped them both under the title NIPPV.

Statistical analyses were performed using STATA (version 14.2, StataCorp, College Station, TX). Two-tailed t and Chi-squared tests were performed for continuous and categorical variables, respectively. Logistic regression was used to evaluate association between continuous variables. The log-rank test was used to compare survival between the subjects in each group. A multivariable regression model was created to adjust for sex, gestational age, birth weight, and days on any respiratory support. P-values and 95% confidence intervals were evaluated when appropriate, using an alpha level of 0.05 to test for statistical significance.

3. Results

286 babies met initial inclusion criteria of BW < 1000g and GA ≤28 weeks. Eighteen died at less than one week of age and 29 were transferred in after one week of age, resulting in 239 infants included in the final analyses. There were 147 infants cared for by the R/F team and 92 by the NNP team. There were no significant differences in subject demographics except for a higher rate of infants with male sex on the NNP team (Table 1, 46.3 versus 59.8%, p = 0.04) and infants on the NNP team spent a mean of 8.5 days longer on NIPPV than those on the R/F team (p = 0.008, CI 2.4–14.6 days).

The difference in NIPPV utilization remained significant when assessing the number of infants receiving any NIPPV, with 54.3% of NNP infants receiving NIPPV versus 26.7% of R/F infants (p = 0.01). There were no differences in the number of infants receiving high-frequency oscillatory (p = 0.61) or jet (p = 0.74) ventilation.

There were no significant differences in length of stay, BPD, PDA, NEC, IVH, sepsis, pneumothorax, discharge on oxygen, death and/or moderate to severe BPD between the two cohorts (Table 2). Fig. 1 shows Kaplan-Meier survival comparisons for the teams which demonstrate no difference in survival between the 2 teams (p = 0.79). There was a significantly lower incidence of severe ROP in babies on the R/F team compared to the NNP team (8.2 versus 18.5%, p = 0.02). This difference remained significant after adjusting for sex, gestational age, birth weight, and days on any respiratory support (OR 0.37,

Table 1
Demographics and baseline characteristics.

	Resident (n = 147)	NNP (n = 92)	P value
Birth Weight (grams)	738 ± 143	744 ± 129	0.740
Gestational Age (weeks)	26 ± 1	26 ± 1	0.803
5-min Apgar	6 ± 2	6 ± 2	0.156
Male	68 (46.3)	55 (59.8)	0.042
White Race[a]	96 (66.2)	71 (78.0)	0.052
Inborn	100 (68.0)	54 (58.7)	0.143
Surfactant Administration	79 (53.7)	54 (58.7)	0.453
Prenatal Steroids[a]	132 (97.8)	83 (96.5)	0.572

Categorical variables described as N (%), continuous as mean ± SD.
CPAP, continuous positive airway pressure; NIPPV, non-invasive positive pressure ventilation; NNP, neonatal nurse practitioner.
[a] Data not available for race in three subjects (two resident and one NNP) and for prenatal steroids in 19 subjects (13 resident and 6 NNP).

Table 2
Clinical outcomes.

	Resident (n = 147)	NNP (n = 92)	P value
Length of Stay (days)	81.4 ± 41.9	82.7 ± 44.0	0.821
All Respiratory Support (days)	31.6 ± 26.7	37.6 ± 30.6	0.120
Invasive Ventilation	23.0 ± 25.0	23.7 ± 25.2	0.833
NIPPV	10.1 ± 8.8	18.6 ± 13.5	0.008
CPAP	4.1 ± 5.9	3.5 ± 5.8	0.438
Days on Oxygen	52.3 ± 41.2	56.6 ± 42.5	0.446
PDA[a]	80 (87.9)	65 (95.6)	0.091
PDA Treatment[a,b]	44 (55.0)	30 (46.2)	0.289
Sepsis	25 (17.0)	12 (13.0)	0.410
Pneumothorax	9 (6.1)	4 (4.4)	0.556
Necrotizing Enterocolitis	16 (10.9)	8 (8.7)	0.584
Severe IVH (Grade 3–4)	6 (4.1)	6 (6.5)	0.418
Periventricular Leukomalacia	4 (2.7)	7 (7.6)	0.079
Threshold Retinopathy of Prematurity	12 (8.2)	17 (18.5)	0.017
Moderate - Severe BPD[c]	70 (51.1)	48 (56.4)	0.251
Death	10 (6.8)	7 (7.6)	0.814
Death or Severe BPD	43 (29.3)	29 (31.5)	0.538

Categorical variables described as N (%), Chi square for categorical variables.
BPD, bronchopulmonary dysplasia; IVH, intraventricular hemorrhage; NNP, neonatal nurse practitioner; PDA, patent ductus arteriosus.
[a] Data based on echocardiographic confirmation and not available in 22 subjects (18 resident and 4 NNP).
[b] Medical (ibuprofen or indomethacin) or surgical treatment.
[c] Only infants who survived to 36 weeks corrected gestational age included in these calculations.

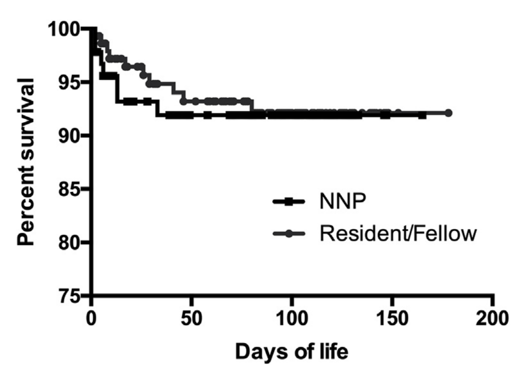

Fig. 1. Survival comparisons between the two groups.

$p = 0.04$, CI 0.14–0.95). Severe ROP was associated with days on oxygen (0.3% increase per day on oxygen, $p < 0.001$), birthweight (4.6% increase for each 100 g decrease, $p = 0.002$), gestational age at birth (6.3% increase for each week decrease, $p < 0.001$), but not days on NIPPV ($p = 0.06$).

4. Discussion

This study confirmed a perception that the NNP team demonstrated increased utilization of some respiratory modalities more than the R/F team. Specifically, there was increased use of NIPPV in ELBW babies cared for by the NNP team compared to the R/F team. Despite this difference, there were no differences in the use of either of the high-frequency ventilation modalities and, more importantly, similar overall clinical outcomes between the two groups. The decrease in severe ROP rates in the R/F team was not clearly associated with any other differences between the teams (i.e. use of NIPPV, male sex), so potential etiologies cannot be derived from the current data.

Several previous studies have compared the practices of NNPs to those of physicians and physicians in training. These studies have demonstrated some differences in management, including that babies resuscitated by NNP-led teams were intubated more quickly and received surfactant sooner ($p = 0.0001$) than babies resuscitated by resident-led teams (Aubrey and Yoxall, 2001) and that NNPs were significantly more effective in detecting abnormalities during physical examinations of neonates (Lee et al., 2001). When assessing outcomes between teams, studies have mostly shown no significant differences (Carzoli et al., 1994) except in cost, where one study demonstrated the care by an NNP group to be $18,240 less per infant than those managed by medical house staff (Bissinger et al., 1997).

The current study confirms previous studies that were performed assessing resident and NNP performance in the NICU, demonstrating that the two groups of providers have similar outcomes (Mitchell-DiCenso et al., 1996; Karlowicz and McMurray, 2000; Schulman et al., 1995). All of those previous studies were performed prior to the institution of the Accreditation Council for Graduate Medical Education resident duty hours restrictions in 2003, however. With concerns that the alteration in duty hours could affect the amount that residents are exposed to clinical care (Desai et al., 2013), it was important to reassess this comparison. The current study is the first contemporary cohort to compare the two groups with those restrictions in place.

This study demonstrated significantly increased number of days on NIPPV in ELBW babies cared for by the NNP team compared to the R/F team. Despite this single difference in use of respiratory modalities, there were no significant differences in surfactant treatments, ventilator days (including high frequency ventilation), or days on oxygen between teams. The reason for increased use of NIPPV on the NNP team remains unclear, although one of the premises leading to this study was a perception among many of the NICU staff that the NNP team was more comfortable with advanced respiratory support. This could have led that team to utilize NIPPV more often than a mode such as nasal continuous positive airway pressure (CPAP) that is more straightforward to manage clinically.

Additionally, the data collected for this study were not able to provide any clear explanation for the unexpected difference in severe ROP between teams. As could be expected from the known pathophysiology, the cases of severe ROP were associated with increased days on oxygen, increased duration of invasive ventilation, and lower birth weight and gestational age at birth. None of these variables were shown to be significantly different between the two groups, however, so were unlikely to be driving the different ROP rates.

This study is limited by its retrospective nature and the lack of true randomization of the patient populations between the two teams. Additionally, there was some overlap in the attending providers caring for the two different teams that could potentially decrease the differences seen between the teams. The latter aspect also highlights the important fact that, although this manuscript might present these as two separate and autonomous groups, they were both part of much larger groups that help to support the providers. These include the bedside nursing staff, dietitians, and pharmacists that round with the teams every day.

5. Conclusions

Overall, this study of a care model including both an NNP team and resident/fellow team demonstrated similar outcomes in the ELBW infants cared for by each team. There was an increase in the number of days the infants on the NNP team spent on NIPPV, and had higher incidence of severe ROP, compared to those on the R/F team that could not be explained by the current data. These data suggest that either model can be safely utilized within a level 3 NICU.

Conflicts of interest

None.

Sources of support

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jnn.2019.04.006.

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