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Comparison of Neonatal Nurse Practitioners' and Pediatric Residents' Care of Extremely Low-Birth-Weight Infants

M. Gary Karlowicz, MD; Jennifer L. McMurray, RN, MSN, CNNP, CPNP

Objective: To compare outcomes and charges of health care delivery to extremely low-birth-weight infants by neonatal nurse practitioners (NNP) and pediatric residents.

Design: Retrospective cohort study.

Setting: A 56-bed neonatal intensive care unit (NICU) in a university teaching hospital.

Methods: Study population included all infants with birth weights less than 1000 g who were admitted to the NICU during the 2-year period between September 1, 1994, and August 31, 1996. Infants who died earlier than 12 hours of age, or who were admitted after 1 week of age or with major malformations, chromosomal abnormalities, or congenital infections were excluded. There were separate teams of NNPs and residents providing care around the clock. The study group included 201 infants with birth weights of less than 1000 g. The NNP team cared for 94 infants and the resident team cared for 107 infants.

Main Outcome Measures: Survival, length of stay, and total charges.

Results: Survival to discharge occurred for 71 NNP team infants (76%) and 82 resident team infants (77%) ($P = .87$). The median total length of stay was 87 days (range, 39-230 days) for NNP team infants and 88 days (range, 41-365 days) for resident team infants ($P = .54$). There were no significant differences between NNP infants and resident team infants in the prevalence of severe intracranial hemorrhage, threshold retinopathy of prematurity, or chronic lung disease at 36 weeks postconceptual age. Median total NICU hospital charges were \$141 624 (range, \$52 020-\$693 018) for NNP team infants and \$139 388 (range, \$50 178-\$990 865) for resident team infants ($P = .89$). There were no significant differences between NNP team infants and resident team infants in NICU charges for laboratory, radiology, or pharmacy services.

Conclusion: Neonatal nurse practitioners and pediatric residents provided comparable patient care to extremely low-birth-weight infants, with similar outcomes and similar charges.

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RESIDENT availability in neonatal intensive care units (NICUs) has been decreasing to assure a broader educational experience in primary care. In fact, the Accreditation Council for Graduate Medical Education and the Residency Review Committee requires that pediatric resident rotations in the NICU be limited to 3 to 4 months in a 3-year training program.¹ Yet, increased survival of very low-birth-weight neonates after the introduction of surfactant² has increased NICU service demands.³ The use of hospital-based generalist and specialist physicians is an expensive alternative. The combination of the increased survival of sicker, smaller neonates and of decreased availability of pediatric residents in the NICU requires consideration

of neonatal nurse practitioners (NNPs) as an alternative.

We are aware of only 1 randomized controlled trial comparing NNPs with pediatric residents in the delivery of neonatal intensive care.⁴ Outcomes and costs for infants on the NNP team were similar for infants on the pediatric resident team. The study's findings were not conclusive because infants assigned to the NNP team were cared for by the NNPs for only 8 hours per day (8 AM to 4 PM) and by pediatric residents for the remaining 16 hours (4 PM to 8 AM). In contrast, infants, who were assigned to the resident's team were cared for by pediatric residents around the clock.

A retrospective study of around-the-clock care by separate teams of NNPs and pediatric residents in the NICU showed no significant differences in outcomes or

PATIENTS AND METHODS

STUDY POPULATION

A retrospective cohort study was conducted of infants with birth weights less than 1000 g, who were admitted to a NICU during the 2-year period between September 1, 1994, and August 31, 1996. The study was a post hoc analysis of prospectively collected data. It was approved by the institutional review board of the Eastern Virginia Medical School, Norfolk. Infants with major congenital malformations or major chromosomal abnormalities were excluded. We also excluded infants who died before 12 hours of age and who were transferred from other NICUs after 1 week of age.

In this teaching hospital NICU, there were separate teams of NNPs and pediatric residents providing care around the clock. The NNP team and the resident team functioned independently of each other with no cross coverage on nights or weekends. They were supervised by the same group of board-certified faculty neonatologists. Each team had a separate attending neonatologist. Admissions were assigned to the NNP and resident teams on an alternating basis, unless one team had a census of higher acuity than the other. If so, the team with the census of lower acuity had more infants admitted to it in an effort to equalize the workload. The team assignment for each new infant was determined by the charge nurse in consultation with the attending neonatologists. In general, team assignment was made by the charge nurse prior to admitting the infant to the NICU. Therefore, an infant's severity of illness, other than having extremely low birth weight, was not known to the charge nurse and did not determine team assignment.

TEAM COMPOSITION, LEVELS OF TRAINING, AND RESPONSIBILITIES

The pediatric resident team was composed of an attending neonatologist and 4 pediatric residents. Usually, there were 3 first-year residents and 1 second-year or third-year resident. Thirty-six pediatric residents rotated through the NICU during the study period. All of our pediatric residents were graduates of American medical schools. Our pediatric residents were assigned 3 to 4 months in an NICU during their 3 years of training. The usual patient load was 5 to 6 patients per resident. Pediatric residents were on call every fourth night for their team, and worked an average of 65 hours per week in the NICU.

The NNP team was staffed by neonatal nurse practitioners, which consisted of 8.5 full-time equivalents who were required to staff the NNP team around the clock. Eleven NNPs worked in the NICU during the study period, several on a part-time basis. The NNPs had a minimum of 4 years of tertiary-level NICU nursing before they attended NNP training. Our NNPs were graduates of a university school of nursing NNP program, but only 2 NNPs had a master's degree. All of our NNPs passed the National Certification Corporation NNP certification examination and

had been certified NNPs for a median of 6 years (range, 1-11 years) at the beginning of the study. No NNPs left the program during the study period. Neonatal nurse practitioners assumed primary health care management of patients in the NICU. Under the supervision of the attending neonatologist, NNPs performed delegated medical tasks including physical assessment, making medical diagnoses, and ordering medications and diagnostic tests. The NNPs performed procedures that included intubation, lumbar puncture, insertion of umbilical catheters and peripheral arterial lines, and insertion of chest tubes. During the daytime, the NNP team was composed of an attending neonatologist and 3 NNPs. The usual patient load was 7 to 8 patients per NNP. One NNP was on call in the hospital for the NNP team overnight. Full-time NNPs worked an average of 44 hours per week.

A board-certified attending neonatologist did in-hospital call from 4 PM to 8 AM and was responsible for both the NNP and pediatric resident teams and was immediately available for any emergencies or admissions.

DEFINITIONS

Threshold retinopathy of prematurity was defined by the criteria of the American Academy of Pediatrics Section on Ophthalmology retinopathy of prematurity subcommittee⁶; that is, stage-3 retinopathy of prematurity, zone I or zone II in 5 or more continuous clock hours, or 8 cumulative clock hours with the presence of "plus disease." Chronic lung disease was defined as the need for supplemental oxygen at more than 36 weeks postconceptual age.⁷ Infants with severe intraventricular hemorrhage, defined as grades 3 and 4 intraventricular hemorrhage, were combined with infants with periventricular leukomalacia for data analysis.

DATA COLLECTION

A neonatal database, which consisted of ongoing prospective abstraction of clinical information from medical records by a research nurse, was the source for demographic and outcome data. Data entry was closely monitored and periodically reviewed by the senior clinical investigator (M.G.K.) for quality-improvement purposes. A hospital database provided charge data. Cost could not be readily determined because there were different conversion factors for different charges and the conversion factors changed several times during the study period. Therefore, cost analysis was not possible and economic analysis was limited to hospital charges.

STATISTICAL METHODS

Parametric data are expressed as means \pm SEMs and were analyzed by *t* test. Nonparametric data are expressed as medians (ranges); comparisons between groups were made with the Mann-Whitney or Wilcoxon test. Categorical data were analyzed using the Fisher exact test. Significance was set at $P < .05$.

charges.⁵ The study included such a heterogeneous population of admissions to the NICU that it would have been difficult to detect significant differences. Furthermore, the study included only 32 extremely low-birth-weight

(ELBW) infants (birth weight, <1000 g). Yet, ELBW infants, as a group, have long lengths of stay, a high rate of adverse outcomes, and incur high charges. We believed that focusing a study on a relatively homogeneous co-

Table 1. Demographics of the Extremely Low-Birth-Weight Infants*

	NNP Team (n = 94)	Resident Team (n = 107)	P
Birth weight, g	754 ± 14	764 ± 14	.63
Gestational age, wk	25.9 ± 0.2	25.8 ± 0.2	.77
Male	52 (55)	53 (50)	.48
African American	76 (81)	71 (66)	.03

*Values for birth weight and gestational age are presented as means ± SEMs. Values for males and African Americans are presented as number (percentage). NNP indicates neonatal nurse practitioner.

Table 2. Outcomes of Extremely Low-Birth-Weight Infants*

	NNP Team (n = 94)	Resident Team (n = 107)	P
Median length of stay, d (range)	87 (39-230)	88 (41-365)	.54
Survived to discharge	71 (76)	82 (77)	.87
Severe IVH or PVL	24 (27)	19 (18)	.17
Threshold ROP	16 (17)	14 (13)	.55
Chronic lung disease	21 (30)	25 (30)	1.0

*Values are presented as number (percentage) unless otherwise indicated. NNP indicates neonatal nurse practitioner; IVH, intraventricular hemorrhage; PVL, periventricular leukomalacia; and ROP, retinopathy of prematurity.

hort of ELBW infants would provide a greater opportunity to detect differences in outcomes and charges between care provided by the NNPs and pediatric residents.

Our objective was to compare outcomes and NICU charges for health care delivery to ELBW infants by NNPs and pediatric residents. Our hypothesis was that there would be no differences in outcomes or charges when there was close supervision by attending neonatologists.

RESULTS

STUDY GROUP

There were 230 infants with birth weights less than 1000 g who were admitted to the NICU during the study period. Twenty-nine infants were excluded. Fourteen infants were excluded because they had major congenital malformations (n=8) or major chromosomal abnormalities (n=6) and were evenly distributed among the NNPs and the pediatric residents. Ten infants were transferred from other NICUs after 1 week of age. Five infants died before 12 hours of age and team assignment was not recorded in the neonatal database.

The study group included 201 infants. The NNP team cared for 94 infants and the pediatric resident team had 107 infants. **Table 1** presents the basic demographic features of infants on each team. There was no difference between teams, except that there were significantly more ELBW African American infants admitted to the NNP team. When all infants admitted to the NICU during the study period were considered, the NNP team admitted 221 African American infants of a total of 445 infants (50%), and the resident team admitted 237 African American infants of a total of 512 infants (46%) (P=.3).

Table 3. NICU Charges for Extremely Low-Birth-Weight Infants*

	NNP Team (n = 94)	Resident Team (n = 107)	P
Laboratory	8383 (2583-33 113)	8612 (3684-68 351)	.61
Radiology	3034 (220-19 275)	2586 (500-15 505)	.20
Pharmacy services	19 194 (993-103 909)	18 084 (5063-111 241)	.64
Bed charges	67 890 (21 979-290 283)	66 950 (11 621-424 798)	.89
Total	141 624 (52 020-693 018)	139 388 (50 178-990 865)	.89

*Costs are in US dollars and are presented as median (range). NICU indicates neonatal intensive care unit; NNP, neonatal nurse practitioner.

OUTCOMES

Table 2 presents the outcomes for infants on each team. There were no significant differences in outcomes between infants on the NNP team compared with infants on the resident team. Post hoc power analysis showed that, with our sample size of at least 94 infants in each group, we would have detected a 20% difference in outcomes between groups with a power of 80% and a significance of P=.05.

CHARGES

Table 3 presents the charges for infants on each team. There were no significant differences in charges between infants on the NNP team compared with infants on the resident team.

COMMENT

Our key findings are that there were no significant differences in major clinical outcomes or NICU charges for infants with birth weights less than 1000 g, regardless of whether the primary health care providers were NNPs or pediatric residents. Our findings are important, because it was projected that 71% of neonatology practices by 1999 would be using NNPs.⁸ Comparable outcomes for NNPs and pediatric residents should be reassuring to parents, nurses, and neonatologists. Comparable charges should be valuable information to neonatologists as well as hospital administrators.

Carzoli et al⁵ reported a trend toward lower total charges for infants cared for by NNPs (P=.23). We did not find any significant difference in total charges between NNPs and pediatric residents. Although cost analysis was not possible, the ratio of costs to charges should not differ between NNP and resident teams because all NICU hospitalizations occurred in the same hospital at the same time. Charges are therefore a reasonable proxy for costs in our analysis.

Mitchell-DiCenso et al⁴ dismissed the need to have a trial of around-the-clock NNP or resident care in the NICU because they believed that it would not have been realistic. Furthermore, they argued that the majority of

management decisions regarding the care of infants in the NICU are made during the daytime. We disagree with their claim. Many critical management decisions in the NICU are made after regular daytime hours, such as when to intubate, start antibiotics, or evaluate for necrotizing enterocolitis. We believe that a trial of around-the-clock care by separate teams of NNPs and pediatric residents is a more accurate model with which to evaluate the NNP's performance, and that it is more relevant to the "real world," given that neonatal intensive care is a round-the-clock activity.

The study by Mitchell-DiCenso et al⁴ provided a relatively large sample size (N=821 infants), and thus resulted in precise estimates of differences in clinical outcomes. Yet, their study population was so heterogeneous, including only 63 ELBW infants, that the mean length of stay was only 12 days. It would have been difficult to detect any significant differences in outcome or charges in comparisons concerning such a heterogeneous study population with a relatively short length of stay. In contrast, our study focused on a relatively homogeneous group of ELBW infants, who were of particular interest because of their high risk of adverse outcomes, their considerably longer median length of stay of 88 days, and high total charges.

African American ELBW infants were admitted to the NNP team significantly more often in our study group. The lack of any difference in the ethnicity of total admissions to the 2 teams makes this event likely to be owing to chance. African American ethnicity does not affect neonatal morbidity or mortality for ELBW infants,^{9,10} so the higher percentage of African American ELBW infants on the NNP team is inconsequential.

Our study shows that there were similar outcomes and charges for health care delivery to ELBW infants regardless of whether care was provided by NNPs or pediatric residents. These findings are consistent with the report that graduating NNPs were similar to second-year pediatric residents in their knowledge of neonatology, clinical problem-solving, clinical skills, and communication skills.¹¹ Owing to its retrospective design, our study of clinical outcomes and charges did not offer any findings relevant to claims from pilot studies that health care delivered by NNPs results in greater parent satisfaction, better documentation,¹² and better communication.¹³ These aspects of health care delivery by NNPs are important and need to be evaluated systemically.

This study was limited in that it was a retrospective nonrandomized trial. However, we believe that the outcomes data were accurate and complete because they were obtained prospectively and closely monitored. The method of assigning new admissions to teams on an alternating basis, including modifications to balance acuity, is not as effective as randomization in avoiding selection bias. Nevertheless, systematic selection bias based on severity of illness was unlikely because the infant's team assignment was made by the charge nurse prior to admission to the NICU, and before severity of illness could be determined.

We could not quantify the amount of supervisory time provided by the neonatologists to the 2 teams because of the retrospective study design. It is likely that

residents required more supervisory time, especially during the first quarter of the academic year as compared with the last quarter. Residents also required additional neonatologist time for didactic sessions, as well as bedside teaching throughout the academic year. The degree of independent decision making allotted to the care providers on the 2 teams varied by individual attending neonatologists as well as by the abilities of individual residents and neonatal nurse practitioners.

This study focused on a relatively homogeneous cohort of ELBW infants to provide greater opportunity for detection of differences in outcomes and charges between care provided by NNPs and pediatric residents. That we found no significant differences in outcomes of care provided by NNPs and pediatric residents, provides strong support for the role of NNPs in NICUs. Our study also demonstrates the effectiveness of pediatric residents in NICUs, despite the fact that their participation has been reduced to 3 to 4 months of a 3-year residency.

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