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Quality Improvement Analysis of Developmental Care in Infants Less Than 1500 Grams at Birth

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The study evaluated the effect of developmental care (DC) on short-term outcome, weight gain, and length of stay in very low-birth-weight infants (1000–1499 grams) and extremely low-birth-weight infants (<1000 grams at birth). The infants were cared for in the neonatal intensive care unit (NICU) at the University Hospital in Cincinnati. It was hypothesized that providing consistent DC to all babies in the NICU weighing 1500 grams or less at birth would increase weight gain and decrease length of stay. Data for both cohorts, predevelopmental care (preDC) and postdevelopmental care (postDC) were collected prospectively as part of the National Institutes of Health Neonatal NICU Research Network generic database on babies less than 1500 grams. This database included all variables studied and used in both cohorts. The study consisted of a pre-DC historic control and post-DC treatment group. The postDC period started 3 months after the entire staff had undergone a 4-day focused educational program on DC. This was done so that the data collected for the postDC group would occur after the initial learning curve for DC in the NICU. This study was carried out in a 50-bed level III NICU in a university teaching hospital setting. Infants weighing 1500 grams or less at birth between July of 1998 and July of 2002 were included. This population was divided into two groups: the preDC group (July 1998-July 2000) and the postDC group (2000–2002). Subgroups were then established by birth weight, less than 1000 and 1000 to 1499 grams, and the second subgroup used to separate groups less than 28 weeks gestational age and greater than 28 weeks gestational age. The total study population consisted of 292 infants. There was a statistically significant increase in weight at 36 weeks of age in the postDC period as compared to the preDC group for both the extremely low-birth-weight and very low-birth-weight groups ($P < .05$). The postDC group had a significant increase in the percentage of infants discharged by 40 weeks postconceptional age ($P < .01$). In conclusion, the successful introduction of a broad practice–based DC program in a university hospital NICU setting is described. This program coincided with significant improvement in weight gain and early discharge in preterm infants less than 1500 grams at birth. This is the first study to incorporate bubble continuous positive airway pressure into a DC regimen and the first National Institutes of Health Neonatal Network site to document positive benefits from the widespread implementation of DC practice across a single NICU.

Keywords: Premature infant; Developmental care; Weight gain; Length of stay; Neonatal intensive care unit

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Developmental care (DC) has been described as "a pervasive orientation of all care procedures toward maintaining the infant in as organized or stable a condition as possible and managing the physical care and social environment to minimize stressors."[1] This practice is a paradigm shift in neonatal intensive care unit (NICU) care, bringing the infants' individual developmental needs and caretaking practices in alignment with physiologic needs, to support the infants' growth and development. Developmental care is a comprehensive transformation of the NICU environment promoting the infants' comfort, growth, and development. As such, it requires total commitment of the entire staff. Developmental care encompasses clinical care and procedures as well as social and physical aspects in the NICU.[2] It is a philosophy of care in which the individual needs of the infant are recognized, prioritized, and supported, so their development may continue as normally as possible in the extrauterine environment. Developmental care creates a supportive microenvironment for the infant within the supportive macroenvironment of the NICU. In an effort to improve the quality of care in the NICU, the task of introducing and educating an entire staff in the research and implementation of DC was undertaken.

Review of Literature

Although DC has become an integral part of patient care in numerous NICUs, the potential benefits have not been extensively evaluated. Studies have variously shown DC to decrease the duration of mechanical ventilation, improve weight gain, shorten hospital stays, decrease incidence of neonatal intraventricular hemorrhage, and decrease hospital costs.[3-5] However, as noted in a systematic review by Symington and Pinelli,[6] many studies were of small sample size and included multiple interventions.

Developmental care involves a combination of multiple philosophies and numerous intervention techniques all focused on the infant as the central figure in the NICU. These strategies are aimed at increasing the infants' comfort and reducing stress in an individualized manner from admission through discharge. These include, but are not limited to, developmentally supportive positioning and handling, recognizing and responding to infant cues, clustering of care and procedures to promote rest, and offering nonnutritive sucking for self-regulation and pain management.[7,8] Light and sound are adjusted according to the needs of the infant in addition to the needs of the staff.[7]

In a position statement by the American Academy of Pediatrics (AAP) in 1997, it was stated that monitoring and reducing noise level in the NICU should be encouraged.[9] Noise levels of more than 55 decibels are of concern and should be avoided.[9] In addition, this AAP statement reported that exposure to noise may disrupt normal growth and the development of normal auditory processing in premature infant. Graven stated, "For the preterm infant it is essential that background neurosensory stimulation (sensory noise) be kept at a level such that sensory systems can discriminate and accommodate meaningful signals or stimulation."[10] Hospitals, therefore, need to provide a means of addressing excessive sound levels.[11]

Many premature infants are exposed to either continuous bright direct light or continuous dim light in the NICU. Current literature supports the use of low-intensity cycled lighting, which reflects the individual infants' developmental needs.[7] This practice has shown that distinct patterns of organized rest-activity are apparent within 1 week after discharge in infants so exposed as compared to those exposed to continuous dim light.[12] Cycled lighting more closely mimics the intrauterine environment where the infant is exposed to maternal circadian rhythm time-of-day cues and hormonal changes that synchronize the fetal clock with the external light-dark cycle.[13] Preterm infants need exposure to light only to facilitate biologic rhythms.[14] Direct bright light should be avoided except during care procedures.[15] The infant's eyes should be covered any time direct light is necessary for care.

Premature infants are at risk for positional deformities acquired in the NICU.[16] The premature infant is often virtually "pinned" to the bed by gravity, exaggerating his already extensor-dominant tone. If the infant is not supported in this intrauterine flexed position, his extensor tone remains dominant and unbalanced. This extended posture is contrary to the intrauterine environment where the infant experiences a predominantly flexed position and is floating in a fluid environment. These acquired positional deformities may lead to developmental motor delays manifesting in the older infant or child.[17] The most common of these deformities include shoulder/scapular retraction with elbow flexion leading to delays in bringing hands to midline and reaching, and hip abduction and external rotation with ankle eversion leading to delays in sitting, crawling, and weight bearing.[17] The very low-birth-weight (VLBW) infant is at risk for postural and tonal abnormalities known to affect developmental motor milestones up to 6 years of age.[18] These positional abnormalities were described as related to immaturity, physiologic hypotonia, and the effects of gravity.[18] Positioning the infant in a contained, more flexed position, mimicking the intrauterine position, while continuing to allow movement against some resistance is optimal to promote a more normal base of support from which all other movement may develop. This type of postural support has both and immediate and lasting impact on the infant's development.[19]

The use of nonnutritive sucking in combination with sucrose for painful procedures has been shown to reduce pain scores during procedures.[20] Although studies have shown that using nonnutritive sucking and sucrose separately can affect behavioral and physiologic responses, it was also demonstrated that they had their greatest effect when used in conjunction. [21]

Methods

Staff Training and Maintenance of Staff Competence

The Children's Medical Ventures' Wee Care Program was introduced as the method of choice for teaching staff not only the research and theory of DC but to assist in practical implementation of this type of care. This education included all NICU staff to facilitate a global change in care delivery, occurring over a brief time frame.

Education was presented in both didactic and hands-on format. It included on-site bedside consultation by the educators for patient-specific questions on all shifts. Implementation of the DC program into the existing structure of this unit was addressed. The program took place over a 4-day period and was designed to promote rapid and uniform exchange of care practice, *making DC a 24-hour 7-day a week practice*.

In this 4-day training period (number of days was based on number of staff), nurses, respiratory therapists, occupational and physical therapists, and physicians attended an 8-hour mandatory program. Many other disciplines were educated in one of several 1-hour sessions. All services were included to ensure that every staff person entering the NICU was aware of how their interactions within that environment can effect the development of the infants. In addition to this initial program, the unit was provided with five 1-day follow-up sessions with a consultant from the educational training team. The topics for these 1-day sessions were chosen based on needs identified as a priority for this individual unit. Topics that were chosen included developmentally supportive feeding, kangaroo care, pain management, and a review of the 8-hour program for new staff. These follow-up visits secured the ongoing efforts of the unit to provide individualized DC.

Any new staff hired since the initial program were required to attend a 4-hour in-service on DC provided by the unit's occupational therapist. Developmental care policies were also written and implemented within 1 year of the Wee Care Program.

The unit's occupational therapist and DC committee continuously monitor the implementation of DC. There is a concerted ongoing effort by the unit to make DC an integral part of the all care received by the infant. Parents are invited and encouraged to actively participate in the infant's care within a framework that supports positive interaction. This allows parents to build confidence in their ability to care for their infants, read their infant's cues, and respond supportively.

Procedure and Study Design

In the predevelopmental care (preDC) group, infants were cared for as per existing standards of care. The policies at that time did not include DC, noise, and light reduction levels or positioning. The postdevelopmental care (postDC) group infants were cared for using the principles of DC taught in the educational program. Comparisons of the preDC and postDC principles are shown in Table 1. All infants in the postDC group were cared for using DC practice from admission through discharge in an individualized manner.

Positioning

Positioning was addressed using the underlying principles of developmentally supportive positioning and using commercial positioning aids as indicated to provide the best support possible and establish consistency among caregivers. The goals of positioning were to provide flexion, containment/boundaries, alignment, and comfort in an individualized manner.

Nonnutritive Sucking

An appropriate-sized pacifier was also used for infants of any age to allow for self-calming through nonnutritive sucking (NNS) and to promote positive sensorimotor input in the presence of necessary but noxious procedures. The practice of providing nonnutritive sucking opportunities during gavage feedings was also implemented. Policies for use of sucrose and nonnutritive sucking were created and implemented.

Lighting

Incubators were covered with quilts made by volunteers to protect the smallest infants from direct light. Lighting was dim and less than 60 foot candles. The lighting was changed to using only "'up lighting," with no continuous direct light over the infant's bed space. The infants' eyes were covered for any procedure in which bright light was needed at the bedside.

Clustering Care/Promotion of Sleep

Care provided to the infant by each discipline was clustered in all non-emergent situations to promote sleep and decrease stress on the infant. Because all staff had been educated, each bedside nurse and caregiver was able to respond to the infants' cues regarding stress and self-calming as these cues occurred.

Table 1. Description of Care in the First Study Period (pre-DC) vs the Second Study Period (post-DC)

No monitoring of sound; all doors to pods open	Baseline sound levels established and sound monitored regularly; doors to pods closed; door buzzer changed; alarm sound levels lowered; intercom system eliminated
Lighting included fluorescent bedside lighting, which was used frequently in addition to indirect lighting, no cycled lighting; incubators covered inconsistently	Use of direct light at bedside eliminated except when necessary for care, then infants' eyes covered; primarily only up lit lighting used, dim during the day, dark at night; all incubators covered
Infants were inconsistently positioned in developmentally supportive manner with inconsistent supply, use of, and understanding of positioning aids	Consistent positioning and handling in developmentally supportive manner with all bedside staff educated in rationale for positioning and use of positioning aids
Inconsistent use of nonpharmacologic pain assessment and intervention	Pain assessed with pain scale and was treated both pharmacologically as previous, as well as nonpharmacologically
Consistent use of NNS for self-calming/regulation; inconsistent staff education regarding signs of stress and self-regulation in premature infants	Continued use of NNS for self-calming/regulation and when indicated, in conjunction with sucrose for painful procedures; all bedside staff educated regarding signs of stress and supporting self-regulatory behavior in premature infants
No formal education of new staff regarding principles, research, and implementation of DC	DC education (both didactic and hands on) became a mandatory class for nursing orientation

Table 2. Maternal and Neonatal Characteristics

	Delivery Weight <1000 grams (ELBW)			Delivery Weight 1000–1500 grams (VLBW)		
	Pre-DC (n = 68)	Post-DC (n = 80)	*P*	Pre-DC (n = 71)	Post-DC (n = 73)	*P*
Maternal race (black)	44%	39%	.51	45%	33%	.13
Antibiotic use	53%	64%	.06	58%	60%	.76
Steroid use	81%	81%	.95	89%	85%	.50
Labor	60%	68%	.36	72%	63%	.26
Cesarean delivery	56%	50%	.48	59%	60%	.89
Delivery gestation (weeks)	26.3 ± 2.2	25.8 ± 1.9	.15	30.5 ± 2.8	29.7 ± 1.9	.02
Outborn	3%	5%	.69	3%	7%	.44
Multiple delivery	22%	18%	.49	227%	18%	.77
Sex (female)	46%	54%	.37	56%	58%	.99
APGAR 1 minute <7	75%	84%	.19	65%	46%	.03
APGAR 5 minutes <7	53%	56%	.69	30%	12%	.01
PDA	44%	52%	.25	18%	14%	.38
NEC	15%	15%	.96	14%	5%	.36
Death	26%	24%	.70	1%	1%	1.00

Data are presented as percentage or mean ± SE. PDA = patent ductus arteriosus, NEC = necrotizing enterocolitis.

Noise Control

Conversation among staff was moved away from the infant's bedside to decrease noise, and alarms were attended to as quickly as possible. Doors that separated the patient care areas from the entryway and documentation area were closed after every pass-through, whereas before DC education they were routinely left open for staff convenience. Staff radios were removed to decrease the overall sound level. Sound was measured routinely with a decibel reader to ensure compliance to AAP recommendations of less than 55 decibels.

Study Design

Institutional review board approval was obtained for this study. Anonymized data for both cohorts were collected prospectively as part of the National Institutes of Health (NIH) Neonatal NICU Research Network generic database on babies less than 1500 grams at birth. This database includes all variables studied in both groups. Respiratory outcomes were not reported as outcomes of the study because of introduction of bubble continuous positive airway pressure (CPAP) during the study period.

The period of the study was from July of 1998 through July of 2002. The study period was divided into two analysis periods: pre-DC and post-DC, 2 years after the introduction of DC. The 3 months just after training and implementation of DC were not used in the study as they were considered a learning period for DC in the unit.

Study Population

This study was carried out in a 50-bed, level III NICU that is part of a 650-bed tertiary care center and teaching hospital.

Infants weighing less than 1500 grams at birth between July of 1998 and July of 2002 were included. Each group was then subdivided by birth weight (BW): less than 1000 grams BW and 1000 to 1499 grams BW. The total study population consisted of 292 infants. Exclusion criteria included death within first week of life, major syndromes or congenital malformations, and those transferred to another facility before discharge home. Those transferred to another facility were excluded because of the lack of data at time of discharge, that is, weight and inability to ensure consistency of DC practice in another facility.

Data Collection Analysis

Data Collection

All infants, preDC and postDC, were part of the generic database collection of infants less than 1500 grams enrolled in the NIH Neonatal Research Network. Thus, the same group of NICU Research Network–trained research nurses collected all data for the preDC and postDC prospectively. There were no changes in the Manual of Operations for data collected during this period. Weight gain and hospital stay were the primary outcomes chosen to act as global measures of improved short-term outcome.

Data Analysis

Data were managed and analyzed using SAS version 8.2 (SAS Institute Inc, Cary, NC) with further analysis done using SUDAAN to allow for the clustering due to multiple gestations included in the analysis and to allow for the estimation of the correct variance. χ^2 and *t* tests were used as appropriate for bivariate analysis of categorical and interval variables. Analysis of covariance was used to adjust birth weight and birth length for gestation, and to adjust weight and length at the equivalent