The Influence of Neonatal Intensive Care Unit Caregiving Practices on Motor Functioning of Preterm Infants

Laurie E. Mouradian, Heidelise Als

Key Words: infant, high risk, infant, low birth weight

Objectives. Experimental design intervention studies have demonstrated that a model of individualized developmental care based on specific behavioral observation improves medical and behavioral outcome for very small preterm infants. It is proposed that infants who were not directly involved in an experimental intervention study per se, but were patients in a neonatal intensive care unit (NICU) where such studies took place and the model was adopted as the standard of care, demonstrate some of the same benefits as the infants in the experimental study.

Method. The study was a retrospective descriptive analysis of an existing data set. The functioning of two cohorts of infants, comparable medically and demographically and cared for in an NICU where developmental care research was conducted and subsequently adopted as the standard of care, was measured after discharge with the Assessment of Preterm Infants' Behavior (APIB). Cohort I was cared for before the first study of individualized developmental care in the NICU; Cohort II was cared for after the individualized developmental care approach was adopted as the standard of care for the NICU.

Results. Cohort II infants demonstrated better scores than Cohort I infants on 8 out of 23 summary variables, 6 of which reflect improved motor functioning. They also showed significantly better scores on 7 of the 17 specific motor variables of the APIB.

Conclusion. Infants cared for in an NICU with an individualized developmental care approach showed improved motor system functioning compared to infants cared for in the same NICU before the approach was adopted. It is speculated that the individualized developmental approach to care based on the synaptic theory of development contributed to the documented improvements. This finding would indicate that functioning of preterm infants, particularly in terms of their motor systems, can be influenced by modification in caregiving.

Over the past several years, there has been a change in philosophy regarding the care and treatment of preterm infants in the neonatal intensive care unit (NICU). Early studies suggested that preterm infants needed stimulation to compensate for their early birth and time spent in the NICU (Kramer, Chamorro, Green, & Knudtson, 1975; Leib, Benfield, & Guidubaldi, 1980). However, other studies demonstrated that preterm infants may be overstimulated, rather than understimulated, by traditional NICU care (Als, 1982; Gottfried, 1985; Lawson, Daum, & Turkewitz, 1977). Als (1982, 1986, 1992) suggested that preterm infants might be best supported by individualized caregiving that is based on each infant's current behavioral strengths and attempts to reduce stress, often an unavoidable concomitant of the need for intensive care.
NICU intervention studies have documented benefits of such individualized caregiving in terms of significantly better medical and behavioral outcome when compared to control group infants (Als et al., 1986, 1988; Becker, Grunwald, Moorman, & Stuhr, 1991). In one of the first intervention studies investigating individualized developmental care, infants in a control group received routine NICU care, while infants in an experimental group received caregiving based on repeated formalized observation of their behavior and resulting written individualized care plans, both based on the synaptic theory of development (Als, 1982, 1986). Both groups were evaluated with the Assessment of Preterm Infants' Behavior (APIB) (Als, Lester, Tronick & Brazelton, 1982b) at 42 weeks after the mother's last menstrual period. In addition to differences in several medical outcome variables (e.g., fewer days on the respirator and fewer days requiring oxygen therapy), infants in the experimental group demonstrated significantly better overall motor organization; better self-regulatory ability; improved ability to cuddle and inhibit crawling motions in prone position; improved muscle tone, motor maturity, and balance of postures; and improved overall behavioral organization and interactive attractiveness. Furthermore, for the experimental group, specific motoric extensor behaviors and the proportion of abnormal reflexes were decreased (Als et al., 1986). A second intervention study (Als et al., 1988) replicated and extended the medical and behavioral results of the first study's findings and again documented a consistent decrease in the proportion of abnormal reflexes, decreased extensor behaviors, and overall improved motor system functioning.

More recently, Becker et al. (1991, 1993) focused on the effects of changes in the NICU environment as well as in caregiving protocols. Both environmental and caregiving changes were based on reduction of stress and support of infant behavioral strengths, as described by Als (1982, 1986). Preterm infants assessed before the implementation of caregiving and environmental changes were compared to preterm infants assessed after the implementation of environmental and caregiving changes. Infants assessed after NICU environmental and caregiving changes demonstrated improvements while in the NICU and at discharge. During hospitalization, infant motor and state behavior was regularly observed and recorded. Infants in the intervention condition showed fewer jerky movements and more flexor movements than infants in the control group (Becker et al., 1993). Intervention infants also demonstrated improvement on medical outcome variables and, at discharge, significantly better performance on the Neonatal Behavioral Assessment Scale (Brazelton, 1984) despite being an average of 2 weeks younger than control group infants at the time of testing (Becker et al., 1991).

Given that Becker et al. (1991, 1993) demonstrated behavioral differences following changes in environmental and caregiving practices, it was proposed that infants who were not enrolled in either intervention study (Als et al., 1986, 1988), yet were cared for in the NICU where the intervention studies were performed, might also have benefited from the changes in NICU practice. Specifically, it was hypothesized that infants cared for after the implementation of individualized development care would show improved APIB scores than infants cared for before that time, thus demonstrating the effect of unit-wide adoption of developmental care as the standard of care.

Method

This study was a retrospective, descriptive analysis of an existing data set that is independent of the experimental studies’ data sets. APIB scores from 20 preterm infants studied before the developmental approach to care was introduced (Cohort I) were compared to APIB scores from 20 preterm infants who were studied after the developmental approach to care was introduced (Cohort II).

Subjects

All infants were white singletons; free of known congenital and chromosomal abnormalities or intrauterine infections; less than 34 weeks' gestational age at birth; appropriate in birthweight for gestational age; without history of intraventricular hemorrhage, bronchopulmonary dysplasia, perinatal asphyxia, seizures, documented central nervous system insult, or other major medical illness or complications; and born to healthy mothers without a history of alcohol or drug addiction. Gestational age for both cohorts was assessed by Dubowitz examination routinely performed within the first 6 hr after delivery (Dubowitz, Dubowitz, & Goldberg, 1970) and confirmed by mother's report of her expected date of confinement.

All subjects were born at Brigham and Women's Hospital in Boston, which has a 46-bed Level III NICU. All infants were at home with their parents by at least 40 weeks postconception and were considered medically healthy (see Tables 1 and 2).

Procedure

All Cohort I and Cohort II infants were examined with the APIB at approximately 2 weeks after expected due date (42 weeks after mother's last menstrual period; see Table 1). Parents were present during the examination. The examinations were performed by experienced, reliable APIB examiners who were unfamiliar with the infant's gestational age at birth. Twenty of the 40 examinations were scored independently by two examiners. Every fifth examination was conducted with the second author present and was scored independently by two examiners to assure continued maintenance of high interrater reliability. Overall Pearson product-moment correlation was .99.
Because this was a retrospective study, none of the examiners was familiar with the hypothesis of the current study.

Intervening NICU Changes

During the time between NICU stays for Cohort I infants and Cohort II infants, two developmental care studies were performed at Brigham and Women’s Hospital, generating several specific changes. Forty of 160 nurses volunteered for formal education and training in behavioral observation of the infant and care plan formulation based on observation (Als, 1984). A new position was created for a developmental clinical nurse specialist whose task was to support the NICU’s primary nursing teams in their implementation of developmental care. The nursing care plan format was revised to include specific documentation of an infant’s functioning along the behaviorally observable subsystems described by Als (1982). Annual performance reviews were modified to include a section on the nurse’s competence in integrating individualized developmental care into daily nursing care. Finally, the concepts of individualized developmental care were included in formal orientation training for all new nursing staff members. Specific caregiving changes observed included the following: positioning of infants in side-lying or prone positions rather than supine position; use of nests made of blanket rolls; reduction of initial time on the open warming tables and early move to incubators; shielding from bright lights and loud noises by use of incubator covers and visors, installation of individual bedside dimmer switch lighting, and reduction of all overhead lighting; elimination of overhead speaker system; dressing and swaddling of infants as soon as they were initially stabilized; emphasis on parents holding and caring for their infant; and 24-hr inclusion of parents and family members in the infant’s care.

Data Reduction and Analysis

The APIB yields 283 raw scores, 202 of which quantify detailed aspects of autonomic, motor, state organizational, attention and orientation, and self-regulatory functioning of the infant. All but one of the 202 specific APIB scores were reduced by a priori rules to 22 summary scores (Als, 1987). One overall behavioral score referred to as Attractiveness was not included in the summary scores. Summary scores are based on a 9-point scale with 1 representing poorly organized behavior and 9 representing well-organized behavior. For analysis in the current study, the summary variables were further grouped into 4 distinct, conceptually based clusters. The clusters were defined as follows:

1. Variables related to autonomic functioning: Three summary variables were included in this cluster, referred to as the Autonomic Cluster.
2. Variables related to motor system functioning: Ten summary variables were included in this cluster, referred to as the Motor Cluster.
3. Variables related to state system functioning: Six summary variables were included in this cluster, referred to as the State Cluster.
4. Variables related to attention and orientation functioning: Three summary variables were included in this cluster, referred to as the Attention Cluster.

In addition to the 22 summary variables, 17 specific APIB scores were selected for analysis. The specific APIB scores chosen described discrete flexor and extensor behaviors quantified in the APIB. Ten of the 17 motor variables represent extensor behaviors. Six of these are scored on a
scale from 0 to 3. They were grouped and referred to as the Extensor Cluster. The remaining four extensor behaviors were scored as being either absent or present. They comprise a group of lower extremity extensor variables known collectively as umbrella variables. The term umbrella is used to describe a posture of leg abduction with possible external rotation of the leg at the hip. The infant’s knees may be flexed or extended. The degree of external rotation, or umbrella posture, is noted for leg position in four conditions: standing, walking, placing with the right foot, and placing with the left foot, resulting in an umbrella score for each of the four conditions. The four variables were grouped together and referred to as the Umbrella Cluster. The remaining seven discrete motor system variables obtained from specific APIB scores represent flexor behaviors. They are scored on a scale of 0 to 3 and were grouped to form the Flexor Cluster.

To test the null hypothesis of equal means between Cohort I and Cohort II, multivariate analysis of variance (MANOVA) was performed. When MANOVA showed a significant difference between Cohort I and Cohort II on a cluster, a one-tailed Student’s t-test was used to compare the individual variables within a cluster of variables. To reduce the likelihood of Type I error, a significance level of .05 divided by the number of variables in a cluster was used to correct for the use of multiple t-tests. Chi-square tests were used to compare the distribution of absence or presence of the umbrella variables for Cohort I versus Cohort II.

Results

Summary Variables

The MANOVA for the Autonomic Cluster showed a significant difference between groups (p = 0.0446; F = 2.97, df = 3, 36). Comparison with individual t-tests showed that none of the three variables in this grouping individually demonstrated a significant difference between groups.

The MANOVA for the Motor Cluster provided evidence of a significant difference between groups (p = 0.0005; F = 4.74; df = 10, 29). Comparison with individual t-tests showed that 6 of the 10 variables demonstrated a significant group difference (see Table 3). Cohort II showed higher scores for 4 variables, indicative of improved performance, and lower scores for 2 variables, also indicative of improved performance. The motor system variables for which higher scores reflect improvement were Motor Maturity, Level of Activity, Capacity to Maintain Motoric Stability During Position Change, and Modulation of Cuddling and Crawling. The two motor system variables for which lower scores reflect improvement were Motor Disorganization and Reflex Performance.

The MANOVA for the State Cluster also showed a significant difference between groups (p = 0.0226; F = 2.88; df = 6, 33). Comparison with individual t-tests showed that one of the six variables in this cluster, Predominant States, was significantly higher for Cohort II infants, again indicating better function (p < .0005).

The overall MANOVA for the Attention Cluster did not show a significant difference between groups (p = 0.0005; F = 2.55; df = 3, 36), therefore individual t-tests were not warranted. The overall behavioral organization variable not included in a cluster, referred to as Attractiveness, was compared by a t-test and showed evidence of a significant difference between groups (p < .001), indicating better overall behavioral functioning for Cohort II infants.

Specific Motor Behaviors

The MANOVA of the specific motor behaviors in the Extensor Cluster showed a highly significant difference between groups (p = 0.0001; F = 11.72; df = 6, 33).

Table 3

<table>
<thead>
<tr>
<th>Variable</th>
<th>Scale Range</th>
<th>Cohort I (n = 20)</th>
<th>Cohort II (n = 20)</th>
<th>t-test</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor maturity</td>
<td>1-9*</td>
<td>3.940 1.176</td>
<td>5.620 1.324</td>
<td>-3.858</td>
<td>.0005*</td>
</tr>
<tr>
<td>Levels of activity</td>
<td>1-9*</td>
<td>4.463 1.839</td>
<td>6.550 1.477</td>
<td>-3.957</td>
<td>.0005*</td>
</tr>
<tr>
<td>Capacity to maintain stability</td>
<td>1-9*</td>
<td>3.031 1.355</td>
<td>4.862 2.014</td>
<td>-3.375</td>
<td>.001*</td>
</tr>
<tr>
<td>Pull to sit</td>
<td>1-9*</td>
<td>4.250 1.803</td>
<td>5.457 2.068</td>
<td>-1.997</td>
<td>.05</td>
</tr>
<tr>
<td>Cuddling and crawling</td>
<td>1-9*</td>
<td>4.226 1.529</td>
<td>5.986 1.215</td>
<td>-4.048</td>
<td>.0005*</td>
</tr>
<tr>
<td>Specific motor acts</td>
<td>1-9*</td>
<td>4.755 1.514</td>
<td>5.500 1.318</td>
<td>-1.699</td>
<td>.05</td>
</tr>
<tr>
<td>Symmetry</td>
<td>1-9*</td>
<td>7.175 1.887</td>
<td>7.450 1.346</td>
<td>-0.557</td>
<td>.25</td>
</tr>
<tr>
<td>Reflex performanceb</td>
<td>0-3*</td>
<td>44.625 16.582</td>
<td>27.186 13.777</td>
<td>3.617</td>
<td>.0005*</td>
</tr>
<tr>
<td>Motor disorganized signals</td>
<td>0-3*</td>
<td>1.617 0.511</td>
<td>0.909 0.610</td>
<td>3.980</td>
<td>.0005*</td>
</tr>
<tr>
<td>Motor self-regulated signals</td>
<td>0-3*</td>
<td>0.902 0.413</td>
<td>1.251 0.448</td>
<td>-2.557</td>
<td>.01</td>
</tr>
</tbody>
</table>

*p refers to scales where 1 is poorly organized behavior and 9 is well-organized behavior.
*Statistically significant difference using a one-tailed Student’s t-test with cut off for significance set at .05/10 = .005 which adjusts for use of multiple t-tests.
Comparison with individual t-tests showed that Cohort II demonstrated a significant reduction on the measure referred to as Airplane, a posture of arm abduction with internal or external rotation at the shoulder and extension of the arm at the elbow. This represents an improvement for Cohort II infants (see Table 4).

Chi-square analysis of the 4 extensor variables from the Umbrella Cluster also showed statistically significant differences between the groups. Cohort II demonstrated a significant decrease in umbrella posture in all four conditions (see Table 5), again indicating improvement in functioning for Cohort II.

Similarly, the MANOVA for the Flexor Cluster showed a significant difference between groups (p = 0.0001, F = 7.59; df = 7, 31). Analysis by individual t-tests showed a statistically significant difference for three variables, with Cohort II showing more Suck Searching, more Sucking, and less Tucking (see Table 6), all indicating improved performance of Cohort II infants.

Discussion

As a group, infants in Cohort II showed more modulated and competent behavioral systems organization. Increased autonomic, motoric, and state stability suggests improved self-regulatory skills and improved differentiation and modulation of function, that is, increased competence. Infants in Cohort II were autonomically and motorically more stable and well regulated. They spent more time in a quiet, alert state, and the quality of social interaction was improved as indicated by improved social responsiveness and ability to engage in social interaction. Additionally, infants in Cohort II showed a decrease in specific extensor postures and an increase in flexor, specifically oral motor, self-regulatory behaviors. The findings presented here suggest that Cohort II infants demonstrated reduced extensor overflow and more effective flexor maintenance, perhaps more similar to the flexor-extensor balance typical of the full-term infant (Casaer, 1979; Prechtl, 1977).

Study Limitations

Although these results are very encouraging, caution needs to be exercised in attributing the improvement in overall behavioral and specific motor system function to the introduction of developmental care as the standard of care. Three issues with retrospective research need to be considered (Kerlinger, 1964): the lack of control of, and inability to manipulate, the independent variables; the lack of power to randomize; and the risk of improper interpretation. Clearly, the lack of control over the proposed independent variable is the major limitation of this study. The dependent variable, APIB scores, was well defined and the similarities between Cohort I and Cohort II on all available medical and demographic variables controlled successfully for possible intervening variables. Nevertheless, one can only speculate as to the agent responsible for the changes noted. The temporal relationship observed between infant behavioral changes and changes in caregiving philosophy is not sufficient to allow one to draw conclusions about causality. Other variables, such as changes in medical care practice, have no doubt also occurred over the time span between cohorts and might have contributed to the improvements seen.

One way to address the concerns about the retrospective design of the current study would be to directly test the proposed independent variable. Als et al. (1986,
Table 6
Comparison of Cohort I and Cohort II APIB Summary Variables: Flexor Cluster

<table>
<thead>
<tr>
<th>Variable</th>
<th>Scale Range</th>
<th>Cohort I (n = 20)</th>
<th>Cohort II (n = 20)</th>
<th>t-test</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td></td>
</tr>
<tr>
<td>Hand clasp</td>
<td>0.425</td>
<td>0.613</td>
<td>0.450</td>
<td>0.686</td>
<td>-0.122</td>
</tr>
<tr>
<td>Foot clasp</td>
<td>0.775</td>
<td>1.045</td>
<td>0.400</td>
<td>0.821</td>
<td>1.262</td>
</tr>
<tr>
<td>Tucking</td>
<td>1.850</td>
<td>1.053</td>
<td>0.895</td>
<td>0.809</td>
<td>3.165</td>
</tr>
<tr>
<td>Grasping</td>
<td>1.750</td>
<td>1.200</td>
<td>1.850</td>
<td>1.182</td>
<td>0.266</td>
</tr>
<tr>
<td>Suck searching</td>
<td>0.775</td>
<td>0.819</td>
<td>2.250</td>
<td>0.567</td>
<td>5.207</td>
</tr>
<tr>
<td>Sucking</td>
<td>1.700</td>
<td>1.010</td>
<td>2.580</td>
<td>0.887</td>
<td>-2.835</td>
</tr>
<tr>
<td>Hand holding</td>
<td>1.650</td>
<td>1.113</td>
<td>2.460</td>
<td>0.754</td>
<td>-2.495</td>
</tr>
</tbody>
</table>

*All variables are scaled from 0, not observed, to 3, frequently observed.
*Statistically significant difference using a one-tailed Student's t-test with cut off for significance set at 0.05/7 = .0071 which adjusts for use of multiple t-tests.

1988) have reported intervention studies with individualized developmental care as the independent variable. Comparison of the results presented in the current study to those obtained by Als et al. (1986) demonstrates notable similarities. Cohort I and Cohort II infants in the present study differed from each other on eight summary variables; infants in the Als et al. (1986) intervention study differed from controls on six summary variables. Of these six, five are identical to those found to differ in the current study: Number of Abnormal Reflexes, Response to Cuddling and Crawling, Motor Maturity, Attractiveness, and Motor Extensor Signals. The current study found group differences on three additional summary variables, whereas the intervention study reported one additional group difference. Given the large number of summary variables studied in both investigations (23 in this study and 24 in the intervention study), it seems unlikely that the similarity of findings is coincidental. The second formal intervention study (Als et al., 1988), which used random assignment of infants to both the control and intervention groups, replicated the findings of consistent decrease in abnormal reflexes and motor extensor signals and of improvement in motor maturity for intervention group infants. The results of these studies support the hypothesis that changes in NICU caregiving have carried over to other, less ill infants in the nursery who were not specifically part of the formal studies' intervention groups. This finding is in keeping with the results provided by Becker et al. (1991, 1993), who demonstrated that the implementation of developmentally supportive care as the standard of care in the NICU produced measurable change in infant outcome.

Future Studies
Continued prospective research is needed to strengthen the argument that individualized developmental care based on the direct observation of each infant's behavior improves outcome. Specifically, in terms of motor system changes, it is speculated that individualized caregiving, based on the behavioral cues of the infant in support of modulated movements and postures, may lead to decreased extensor overflow. Improved flexor-extensor balance, in part presumably musculogenic in origin, is perhaps aided by improved positioning, which promotes flexion. This possibility is supported by the finding that infants positioned with hip support demonstrate less lower extremity abduction and external rotation than infants given no posterior support (Downs, Edwards, McCormick, Roth, & Stewart, 1991). It will be the task of future research to identify the specific factors entailed in developmental care that contribute to the motor system differences observed.

Relevance for Occupational Therapy
The study reported here is but one instance of a growing body of literature supporting the implementation of individualized developmental care. This model of care and the synactive theory of development on which it was based show promise as a conceptual foundation upon which the therapist can build observation, assessment, and support skills to meet the many challenges of providing developmentally appropriate individualized care for infant and family. Such care offers the occupational therapist an opportunity to integrate a developmental model into a setting in which therapy services have frequently been delivered in a more traditional acute care medical model, appropriate to rehabilitation settings but not to meeting the needs of the rapidly developing preterm newborn population in the NICU. Specialty training in observation, formal assessment, and preventive as well as therapeutic programming for the high-risk preterm infant in the NICU emerges increasingly as an opportunity in the NICU setting. Through the individualized developmental approach to care, the occupational therapist can play a leading role as educator and facilitator of developmental care in the NICU.

Conclusion
Although the agent responsible for the behavioral and
specific motor system improvements seen in Cohort II infants cannot be conclusively determined, the findings of the current study are in keeping with and extend the findings of formal intervention studies reported in the literature. Together, these studies suggest that changes in caregiving within a unified conceptual individualized developmental framework appear to improve behavioral outcome, particularly in terms of the motor system, increasing overall motor system modulation and reducing extensor patterns.

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