SECTION 4. EMOTIONAL CARE OF THE AT-RISK INFANT

Early Interventions for Infants of Depressed Mothers

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ABSTRACT. Infants of mothers who remain depressed for 1 year after birth have a distinct profile of behavioral, physiologic, and biochemical dysregulation. Their mothers also have a distinct profile that can be used to target those in need of intervention. These interventions may include mood induction, massage therapy, interaction coaching, and natural buffers such as nondepressed fathers and caregivers. Pediatrics 1998;102:1305–1310; mothers, infants, depression, intervention, mood induction, EEG, massage therapy, cortisol, vagal tone.

ABBREVIATION. EEG, electroencephalography.

Infants of mothers who remain depressed for 1 year after birth show a distinct profile of behavioral, physiologic, and biochemical dysregulation. Their mothers also have a profile that can be used to identify those mothers who are likely to remain depressed and to target high-risk mother–infant dyads in need of intervention. This article of New Perspectives in Early Emotional Development reviews data on identifying mothers who remain depressed; dysregulation in infants of depressed mothers; and interventions, both brief and intensive.

Recent research suggests the following:

- Maternal depression can negatively affect infants as early as the neonatal period, implicating prenatal effects of maternal depression.
- Infants show a profile of dysregulation in their behavior, physiology, and biochemistry that may be attributable to prenatal exposure to a maternal biochemical imbalance.
- These effects are compounded by the disorganizing influence of the mother's interaction behavior.
- Depressed mothers have two predominant interaction styles, withdrawn or intrusive, that seem to have differential, negative effects on their infants because of inadequate stimulation and arousal modulation.
- Nondepressed caregivers such as fathers may buffer these effects because they provide more optimal stimulation and arousal modulation.
- Interventions that are mood-altering for the mothers and arousal-reducing for the infants (eg, music and massage therapy) make them more responsive to interaction coaching and improve their interactions.

The interventions we have been studying may be effective because 1) they induce a better mood state in the mothers (and alter right frontal electroencephalography [EEG], a marker of depression) and lower stress hormone (norepinephrine and cortisol) levels; 2) they reduce sympathetic arousal in the infants; and 3) reduced sympathetic arousal leads to improved responsiveness, greater availability to interaction coaching, and improved interactions.

DEPRESSED MOTHERS

Of the depressed mothers we studied, 70% had chronic depression that persisted during their infant's first 6 months of life. These infants showed delays in growth and development at 12 months. Physiologic/biochemical markers for the mothers' chronic depression included relative right frontal EEG activation; low vagal tone and serotonin; and elevated norepinephrine and cortisol levels. Measurement of these variables at 3 months accounted for 51% of the mothers' continuing depression at 6 months (with mothers' right frontal EEG activation alone explaining 31% of the variance).

Because infants whose mothers remained depressed at 6 months had growth and developmental delays at 1 year, it is important to identify those mothers for intervention purposes. In our sample, simple electrocardiography, EEG, and urine analysis (for cortisol, norepinephrine, and serotonin) could explain more than half the variance in the mothers' continuing depression. These measures also could be used to identify those mother–infant dyads needing early intervention.

NEWBORNS OF DEPRESSED MOTHERS

Infants of depressed mothers appeared to have profiles of dysregulation as early as the neonatal period. These profiles are characterized by:

- limited responsivity on the Brazelton scale, excessive indeterminate sleep, and elevated stress hormone (norepinephrine and cortisol) levels in the neonatal period;
- right frontal EEG activation at 1 week, 1 month, and 3 months; stability in these patterns from 3 months to 3 years;
- limited responsivity to facial expressions, lower...
vagal tone, and signs of neurologic delays at 6 months;
• less social referencing at 9 months\textsuperscript{10}; and
• limited play and exploratory behavior,\textsuperscript{11} inferior Bayley scores,\textsuperscript{1} and delayed growth at 12 months.\textsuperscript{1}

Evidence for physiologic dysregulation in infants of depressed mothers has been noted as early as 1 week of age and is characterized by relative right frontal EEG activation, lower vagal tone, and less mature sleep patterns.\textsuperscript{8}

Disturbed Sleep–Wake Behavior
In our studies at the Touch Research Institute, newborns of depressed mothers showed inferior performance on the Brazelton scale for orientation (particularly on inanimate items), depression, and robustness, and they demonstrated more stressed behavior\textsuperscript{4,12} (Table 1). They also showed excessive indeterminate sleep (sleep that is difficult to code), which is disconcerting given the findings of Sigman and Parmelee suggesting an inverse relationship between the amount of indeterminate sleep during the neonatal period and IQ scores at 12 years.\textsuperscript{13} Finally, they were less attentive and less expressive when exaggerated faces were modeled for them and their looking behavior and mimicry were recorded.\textsuperscript{12}

Sympathetic Activation
During the neonatal period, stress hormones (norepinephrine and cortisol) were significantly elevated in both depressed mothers and their infants. Differences continued across the first several months.\textsuperscript{3,14}

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\textbf{FETUSES OF DEPRESSED MOTHERS}

The need to identify chronically depressed mothers during pregnancy and evaluate the behavior of their fetuses was highlighted in a report by Field and colleagues. In this study, biochemical profiles in newborns matched their mothers’ prenatal biochemical profile.\textsuperscript{2} During the third trimester of pregnancy, the depressed mothers’ norepinephrine and cortisol levels were elevated and their dopamine levels were lower than those in nondepressed mothers. Assays of their newborns’ catecholamine and cortisol levels suggested that they also had elevated norepinephrine and cortisol and depleted dopamine levels.

In a subsequent study, we identified chronically depressed mothers during the third trimester of pregnancy. Again, catecholamine and cortisol levels were assayed, and a similar pattern was noted. Fetal sonograms were evaluated for activity levels and responses to vibrotactile stimuli. Fetuses of the depressed mothers were less active; they had weaker responses to vibration, and their weight was estimated to be significantly lower.

\textbf{INFANTS OF DEPRESSED MOTHERS}

\textbf{Right Frontal EEG Activation}
Assessments of EEG asymmetry in mothers and infants revealed a pattern that is noted in chronically depressed adults, namely, more right frontal EEG activation and less left frontal activation (in both the mothers and their infants) when the infants were 3 months old,\textsuperscript{15} 1 month old,\textsuperscript{16} and even as young as 1 week old.\textsuperscript{5} Right frontal EEG at 1 month also was related to indeterminate sleep patterns and negative affect in the neonatal period\textsuperscript{8} (Fig 1). That the depressed mothers showed relative right frontal EEG activation is not surprising, but the appearance of this pattern in their infants as early as 1 week was very unexpected, given the supposed plasticity of brain development during the first several months of life. In addition, this pattern appeared to be stable in infants of depressed mothers, at least from 3 months to 3 years of age.\textsuperscript{8}

\textbf{Depressed Vagal Tone}

Lower vagal tone has been reported for 6-month-old infants of depressed mothers.\textsuperscript{15} Specifically, a developmental increase in vagal tone that occurred between 3 and 6 months in infants of nondepressed mothers did not occur in the infants of depressed mothers. Lower vagal tone at 6 months also correlated with fewer vocalizations during interactions and less optimal neurologic ratings, suggesting diminished autonomic development and control in infants of depressed mothers. Lower vagal tone also has been noted in 3-month-old infants of depressed mothers during their interactions with their mothers or nondepressed strangers.\textsuperscript{17}

Vagal tone could be responsive to contextual factors such as stress and changes in attention during interactions, and these factors could be different for infants of depressed and nondepressed mothers. For example, depressed mothers are notably less expressive, and their infants may become agitated in their attempts to elicit more expression. Whether the differences are neuroregulatory or reflect different demands in the interaction situation is unclear. The absence of a developmental increase in vagal tone in infants of depressed mothers could relate to cumulative effects of maternal depression, including the continuing elevated norepinephrine levels noted in these infants.

Another complex finding emerged in a study in which both facial expressions and vagal tone were recorded.\textsuperscript{15} Here, interest and joy expressions were significantly correlated with vagal tone in infants of nondepressed mothers; however, infants of depressed mothers had more negative behaviors (including gaze aversion and sad or angry expressions) and also were positively correlated with vagal tone.
At 6 months, vagal tone was significantly lower and behavioral responses to facial expressions were slower in the infants of depressed mothers. Although the significance of lower vagal tone is not entirely understood, higher vagal tone typically is associated with better performance on attention and learning tasks.

Laboratory Studies of Affect Perception/Production

In affect perception/production studies at the Touch Research Institute, we have learned that:

- Depressed mothers exhibit fewer positive faces and fewer animated faces and voices.
- Infants of depressed mothers produced more sad and angry faces and showed fewer expressions of interest. They also showed a preference for sad faces/voices (greater looking time at videotaped models looking and sounding sad), which might relate to sad expressions being more familiar to them. They also displayed less accurate matching of happy facial expressions with happy vocal expressions.
- The absence of a relationship between infant facial expressions and vagal tone in infants of depressed mothers suggests biobehavioral uncoupling that might derive from the infants’ excessive vigilance in emotional situations.

Later at 1 year, during a “mother holding doll” situation, infants of depressed mothers showed less protest behavior.

Developmental Delays

By 12 months, more infants of depressed mothers had neurologic soft signs and showed less exploratory behavior, lower Bayley Mental and Motor scale scores, and lower weight percentiles.

Chronic Depression Markers Used To Identify Highest Risk

In our 6-month longitudinal study (138 depressed dyads, 84 nondepressed dyads), regression analyses yielded several reliable markers of the mothers’ chronic depression at 6 months’ postpartum. These included right frontal EEG activation at 3 months, lower vagal tone and serotonin, and elevated norepinephrine and cortisol levels during the neonatal period.

Longitudinal Follow-up

In our longitudinal follow-up sample at 3 years, 75% of the mothers with high scores on the Beck during the neonatal period still had elevated Beck scores. Their preschool children continued to show interaction problems, and on the Children’s Behavior Checklist, they scored in the clinical range for externalizing and internalizing factors. They also had elevated cortisol levels and were considered vulnerable by their mothers. Early infancy predictors that may contribute to this perceived vulnerability included the ratings of the infants’ interactions with strangers and their heart rate variability at 3 months. In a follow-up study on stability of relative right frontal EEG activation, 3-month-old infants with right frontal EEG continued to have the same pattern at 3 years. The 3-year-olds with relative right frontal activation also were more inhibited in strange object/strange person situations, and they showed nonempathetic behavior during their mothers’ display of distress (crying).

EFFECTIVE INTERVENTIONS

Natural Buffers of the Depressed Mothers’ Negative Effects (Fathers and Nursery School Caregivers)

Natural buffers in the environment for infants of depressed mothers included putative fathers/boyfriends and nursery school teachers. Infants of depressed mothers received better interaction ratings with their nondepressed fathers (Table 2) and their nursery school teachers than with their mothers. Fathers also can help overcome the negative effects of depression, as improvement is noted when infants of depressed mothers interact with their fathers. The fathers showed more positive facial expressions and vocalizations than did mothers and, in turn, the infants showed more positive facial expressions and vocalizations when interacting with their fathers. These data suggest that nondepressed fathers and nondepressed nursery teachers can compensate for the negative effects of depressed mothering.

The Touch Research Institute study on switching mothers, which asked whether depressed infants improved when interacting with nondepressed mothers and whether depressed mothers showed more responsive behavior with infants of nondepressed mothers, yielded very few group differences. The infants’ “depressed” behavior generalized to the
nondepressed mother, possibly because interacting with strangers was stressful for the infant.17 Interestingly, depressed mothers did not negatively affect the infants of nondepressed mothers, suggesting that normal infants might be less vulnerable to unresponsive interaction behavior than are infants of depressed mothers.

**Massage Therapy for Infants**

Massage therapy was an effective intervention for the infants of depressed mothers. In contrast to rocking, massage therapy contributed to more organized sleep patterns, more positive interaction behaviors, and greater weight gain.26 Forty full-term 1- to 3-month-old infants born to depressed adolescent mothers were given 15 minutes of either massage or rocking on 2 days per week for 6 weeks. Compared with rocked infants, massaged infants spent more time in active alert and active awake states, cried less, and had lower salivary cortisol levels, suggesting lower stress. Immediately after the massage, the infants spent less time in an active awake state, suggesting that massage therapy may be more effective than rocking for inducing sleep. During the 6-week period, the massage therapy infants gained more weight; showed greater improvement on emotional-, sociability, and soothability temperament dimensions; and had greater decreases in stress hormones (norepinephrine, epinephrine, and cortisol) and increased serotonin levels (Table 3).

**Mood-induction Interventions for Mothers**

For the mothers, music therapy27 and massage therapy26 sessions were extremely effective short-term interventions. Chronically depressed adults have relative right frontal EEG activation that remains when their behavioral symptoms are in remission, suggesting that this pattern would be difficult to alter. However, after only 20 minutes of music (in this case, rock music), 10 of the 12 depressed mothers showed an attenuation of right frontal EEG activation, moving toward symmetry or toward left frontal activation (Fig 2). The two adolescents whose EEG pattern did not change claimed that they did not enjoy the rock music. When their favorite music (classical) was played, they too experienced a shift toward symmetry.

Although it is not clear how prolonged these effects may be, it was surprising that the relative right frontal EEG activation, thought to be a marker of chronic depression, could be altered by only 20 minutes of music. Both types of therapy led to attenuated
right frontal EEG activation. These results were surprising, because EEG had been considered unalterable in adults and frontal EEG is a marker of chronic depression. However, more recent positron emission tomography data on blood flow suggest that frontal cortex activity might reflect a difference in mood state, whereas differences in the amygdala might reflect chronicity.

**Interaction Coaching**

Studies have shown that imitation and attention-getting instructions are effective in improving mothers’ interaction behaviors. Mothers became more animated when trying to get their infants’ attention and more sensitive to their infants’ signals when imitating them. The infants, in turn, became more responsive. In a subsequent study, we noted that interventions were differentially effective with different (withdrawn/inhibited) depressed mothers. Interventions were most effective when tailored to the mother’s style: for example, using imitation with an intrusive mother was effective in “slowing her down.”

**Lifestyle Intervention Study**

Mothers and infants were followed for their first 6 months to assess the infant’s development and identify potential markers in the first 3 months that predicted chronic depression in the mother. The markers then were used to identify a second sample of chronically depressed mothers who received an intervention composed of social/educational/vocational rehabilitation, mood induction (including relaxation therapy, music mood induction, massage therapy, and interaction coaching), and infant day care.

Although the intervention mothers continued to have higher depression scores than the non-depressed mothers, their interaction behavior became significantly more positive and their biochemical values and vagal tone normalized (or approximated the values of the non-depressed control group) (Table 4). The infants in the intervention group also showed more positive interaction behavior, better growth, fewer pediatric complications, and normalized biochemical values; by 1 year, they had superior Bayley Mental and Motor scores. Thus, chronically depressed mothers could be identified and were offered a relatively cost-effective intervention that attenuated the typical delays in growth and development. Finally, although there was limited success in modifying depressed mothers’ relatively flat facial and vocal expressions, we were able to increase their touching behavior. This in turn improved the mother’s mood state and interaction behavior, as well as their infant’s interaction behavior.

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