

# MUSIC LISTENING IN NEONATAL INTENSIVE CARE UNITS

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The hospital care of premature, low birth weight infants requires large resources in technology and personnel. The economic cost of care in the United States for Neonatal Intensive Care Unit (NICU) and Intermediate ICU averages between \$1,000 and \$2,000 per day or over 3.5 billion dollars a year. The added costs of special education and continued cost of medical care for these children are larger than the initial costs for their NICU care (Lewit, et.al., 1995). Many of these babies suffer hearing and visual disabilities, mental retardation, cerebral palsy or learning disabilities.

Over the last two decades there has been a marked increase in the population of low and very low birth weight infants. These infants are deprived of their normal intrauterine environment and they are susceptible to the effects of stress in the NICU. The adverse effects of stress in the NICU are reflected by heart rate variations, increasing oxygen consumption and decreased blood oxygen levels as well as marked blood pressure fluctuations, failure to thrive, and increased levels of agitation. The NICU infant cannot always communicate the feeling of pain, yet when pain is sensed this sets off a stress reaction,

which includes an increase in stress hormone levels (Arnand and Hickey, 1987).

While it is felt that sensory stimulation is necessary for optimal neurological development, the sights and sounds of the modern NICU provide an inappropriate sensory environment for the premature infant (Collins, 1996). An infant in the NICU is exposed to average ambient noise levels ranging from 50 TO 88 dB, with peak levels of over 100 dB from sources such as ventilators, monitor alarms, incubator fans and motors, conversations, radios, telephones, water faucets, and cabinet doors (Lynam, 1995). The act of closing an incubator porthole can reach over 110 dB, or the equivalent of a riveting machine. Loud noise and abrupt peaks in sound levels can be highly arousing for the medically fragile premature baby. Subsequently, conditions such as hypoxemia, blood pressure instability, increased apnea and bradycardia, altered cerebral blood flow, and a predisposition for intraventricular hemorrhage can occur (Lynam, 1995). Besides causing distress, these sounds can inhibit sleep-wake cycles and prevent descent into REM sleep states necessary for maturation and weight gain.

Since the 1980's, a number of studies have looked at the institution of developmental care, in the NICU (Als,et.al., 1994, Petryshen,et.al, 1997). This approach recognizes the importance of the environment and the appropriate level of stimulation necessary to foster brain growth and to integrate physiological and behavioral processes. Developmental care incorporates light and noise management, positioning/bundling, use of pacifiers, kangaroo care consisting of skin contact with mother or caregiver, and "clustering" of stimulative procedures, allowing for delineation of awake and restful state cycles. Some of the very significant benefits of developmental care are improved clinical outcomes as well as faster weight gain, earlier discharge from the hospital, and significant decreases in the cost of hospitalization. The inclusion of playing music and other sounds is a natural extension to

the practice of developmental care.

In order to understand what is an appropriate environment to strive for in the premature baby one can look back at the environment that the premature baby abruptly loses. The intrauterine environment plays an essential role in the growth and development of the fetus. The whole "nature vs. nurture" controversy has ignored the influence of the womb on intelligence and personality. Most previous studies have looked at identical twins in examining genetic and environmental effects on intelligence. The assumption in these studies were that identical twins that are separated in infancy share only genetic effects on their intelligence. This approach ignored the shared environment these twins shared in the womb. A meta-analysis of 212 studies spanning the last 70 years showed that the womb accounts for 20% of the shared IQ component of these identical twins separated at birth. (Devlin, Daniels and Roeder, 1997). This explains the striking correlation between the IQ's of twins, especially those of adult twins raised apart. The explanation for this is that a significant amount of learning takes place in the uterus. There is no doubt that intrauterine auditory stimuli contribute a large part of this environment.

## EVIDENCE FOR INTRAUTERINE HEARING AS MAJOR SOURCE OF LEARNING

Ultrasound studies have shown that at 16 weeks gestation the fetus can respond to outside sound (Hepper, 1994, Shahidullah and Hepper, 1992). Hearing is the first sense to develop and the last to deteriorate in the life cycle. Babies learn to adapt to their mother's breathing, her movements, and her voice as she speaks or sings. The sounds of the blood flow through the placenta can be heard at a very loud level in the womb. For the lower sound frequencies below 500 Hz, mean sound levels are 80 decibels with peaks to 95 decibels (Gerhardt and Abrams,

1996). This is about as loud as it gets on a crowded dance floor on a Saturday night. The fetus hears the mother's heartbeat about 26 million times. This rhythm protects us, and throughout our lives it will attract us as one of the most important components of music, because it symbolizes primary security and dependable return (Decker-Voigt, 1997).

Evidence points to the fact that learning extends back into the prenatal period, and that the sounds and rhythms in the womb may contain information important to the development of the fetal brain (Devlin, Daniels and Roeder, 1997, Shetler, 1989). The newborn can differentiate a recording of his own mother's prenatal womb sounds from a recording of another mother (Righetti, 1996). The newborn can also differentiate emotional content in the recording of his prenatal womb sounds and respond with changes in movement and heart rate (Righetti, 1996).

There is a vast amount of potential information available to the fetus that can be given in the playing of just one musical note or in singing or talking a single syllable. The content of this sound is full of informational and emotional content (Schwartz, 1997). The fetus and newborn have an innate capacity to perceive this information at a very deep, profound level. To label an interaction with a newborn as infantile is to ignore the genuine receptivity of the newborn, who is already prewired for the reception of love, nurturing and emotional wisdom. These communicative processes which take place before and after birth contribute to the promotion of the child's physical development, behavioral characteristics and level of intelligence (Lipton, 1998).

The synaptic network in the fetal brain as well as the infant brain undergoes learning dependant reorganization. This process involves synaptic pruning, the regression of neural circuits as well as the synaptic sprouting of the developing brain. There is a substantial reduction in neurons and synaptic connections that occurs during the

last trimester as well as a more modest reduction during childhood. This is consistent with the observation of psychologists that infants and children may have enhanced behavioral abilities that diminish later in life (Johnston, 1995). Since fetal hearing is probably the major component of this learning dependent synaptic pruning and sprouting, the fetus is participating in a 2<sup>nd</sup> and 3<sup>rd</sup> trimester auditory amphitheater that is perhaps more important than any other classroom. It is apparent that we have only begun to explore the connection between sound and neurobiological development in the fetus and newborn.

## **STUDIES ON NICU MUSIC**

Some of the hindrances to growth and earlier discharge from the NICU are decreased blood oxygen availability and increased oxygen consumption from stress. The increased stress response also consumes precious calories. The use of music in the NICU has been shown to decrease the stress response and increase oxygen levels. Womb sound music has been shown to be helpful in the care of mechanically ventilated, agitated premature babies with low oxygen levels. Significant increases in oxygen saturation as well as decreased levels of agitation were found with the use of music (Collins and Kuck, 1991). Another study showed that when lullaby music was played in the neonatal intensive care unit (NICU) that there were less episodes of oxygen desaturation (Caine, 1991).

There is no doubt that some of the high decibel sounds from alarms and equipment in the NICU are harmful to the neonate. In one study a group of premature babies were insulated from their audio environment with earmuffs (Zahr and Traversay, 1995). They had higher oxygen saturations and more time in the sleep state compared to a control group. Several studies using music with premature babies in the NICU

have shown a 3 to 5 day earlier discharge from the NICU (figures 1, 2 and 3, Caine, 1991, Coleman, Pratt and Abel, 1998, Standley, 1996). Other studies have shown a doubled daily weight gain when premature babies in the NICU were exposed to music therapy (figure 1, Coleman, Pratt, et.al., 1998, Standley, 1998, Caine, 1991).

## Vocal lullabies decrease length of hospital stay in NICU patients

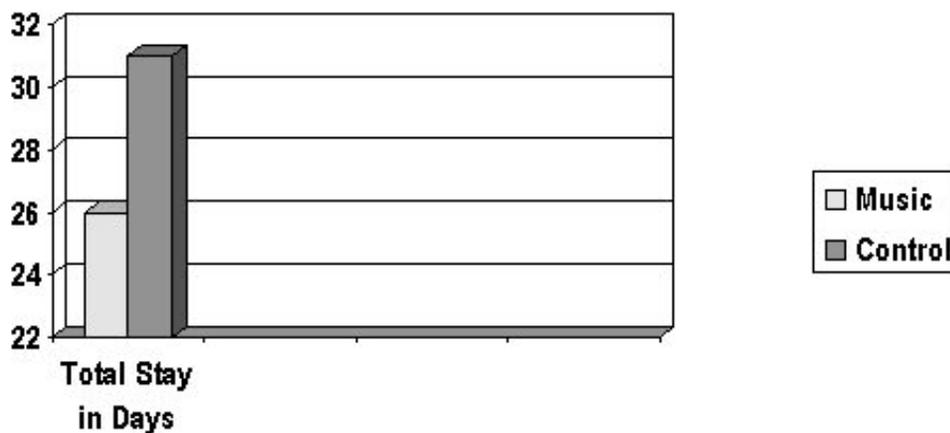


Figure 1

Modified from Caine, 1991

## Vocal lullaby music increases weight gain and average 3 day earlier discharge from NICU

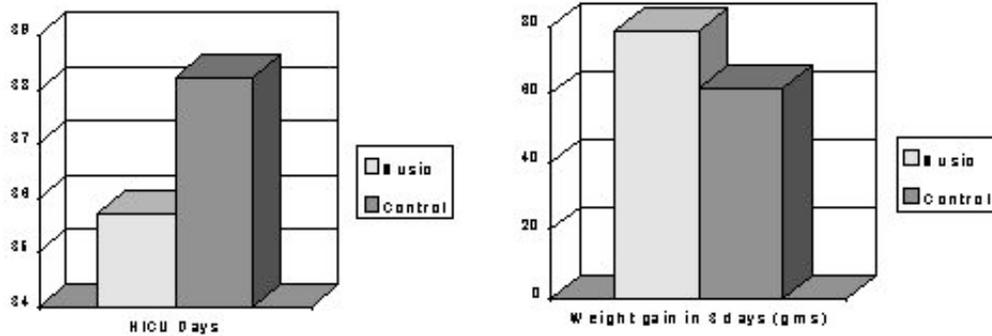


Figure 2

Modified from Coleman, Pratt, et.al., 1998

## Music and multimodal stimulation decreases hospital stay

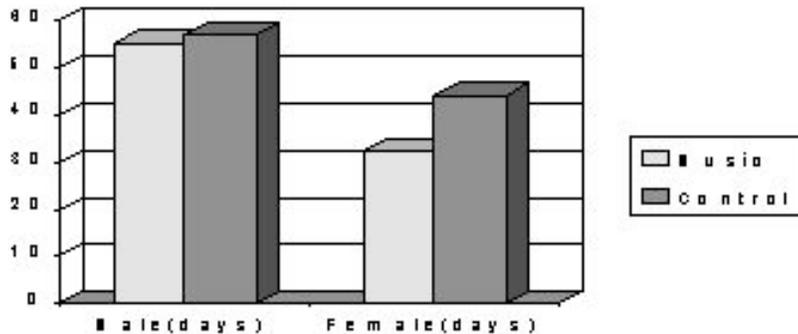


Figure 3

Modified from Standley, 1998

Previous studies have been inconsistent in regard to weight gain changes with music (Standley, 1996). A gender difference as far as music benefits have been observed in most studies, with the benefits of music predominantly benefiting the female babies (Standley, 1998). This can probably be explained by the fact that newborn girls have more sensitive hearing than boys at birth (Cassidy, J.W. and Ditty, K.M., 1998).

After music was introduced in our NICU at Piedmont Hospital in early 1998, we noticed a trend for faster growth of head circumference (HC) in our premature babies exposed to music (Schwartz, 1998). In a post hoc analysis this effect of music on HC growth was found to be significant in Dr. Jayne Standley's study on effect of music and multimodal stimulation in the NICU (Standley, 1998).

It seems logical that the early loss of the intrauterine sound environment would affect brain maturation in the premature baby. Previous work on prenatal intrauterine sound stimulation has shown increases in newborn head circumference and developmental abilities (Logan, 1991). Head circumference is a reliable indicator of brain size in the first 2 years of life (Sheth, 1995, Bray, 1969). We know that malnutrition during infancy leads to reduced head circumferences and IQ,s later in life (Winick, 1969). There is a definite negative effect on cognitive abilities in the very low birth weight baby (<1.5 kg.) with subnormal head growth in whom catch-up growth does not occur. Decreased head circumference at age 8 months is a strong predictor of decreased intellectual capacity at eight years of age (Hack, 1991). Low birth weight babies who do not catch up in their HC growth have decreased cognitive abilities later on.

Since it appears that we can foster increased brain growth along with increased synaptic connections in premature babies with music stimulation, the implications are that we can use music to decrease the developmental delays that are common in premature babies. It has been shown that by exposing premature babies to a recording of the baby's own mother's voice in the hospital, the results at age 5 months showed a significant enhancement in verbal and motor development (Nocker-Ribaupierre, 1999, 1995). At age 20 months there remained a trend for these infants to maintain these leads in verbal and motor development despite a small sample size (24 patients control, 24 patients audio stimulation). At age 6 there was still a trend for better verbal skills in the stimulated group.

It becomes clear that there is indeed an effect of music and sound on brain development which extends as far back as the fetal period. This is a natural extension of the "Mozart Effect" in preschool children, showing that music training can enhance language development,

spatial and mathematical abilities (Rauscher, et al,1997), as well as work that showed exposure to Mozart increased spatial IQ in college students (Rauscher, Shaw and Ky, 1995).

The newborn baby, and especially the premature baby have a distinct framework of experience with sounds and music. We know that newborns prefer female voices to male voices, and prefer their own mother's voice to other women's voices. Some of the most commonly used audio stimulation in the NICU have been lullabies, classical and womb sound music, as well as mother's spoken voice and singing. Previous studies on the use of music with premature and term babies have mostly looked at the benefits of lullabies, classical and womb sound music (Cassidy and Ditty, 1998). Musical selections for fragile premature babies must be carefully considered. The emphasis must be given to simplicity, as well as gentle rhythms, flowing and lyrical melodies, simple harmonies, and a soft tone color. Transient changes in amplitude must be avoided, as well as abrupt tempo changes. Complexity of sound timbre and color should be avoided as well as complex combinations of different instruments. However, the premature baby responds to quality and precision of musical expression, and has the capability of responding to a beautiful recording which expresses love and wisdom.

What tradition is as old, or as universal, as that of singing lullabies to our babies? All families within all cultures from the beginning of time have "lulled" their young ones to sleep with song (Boyd, 1994). The word "lullabye" itself comes from two roots buried deep in the history of the english language. "Lulla" means to soothe and is still used today in the verb "to lull". It may have had it's origin in onomatopoeia because it is easy to imagine a parent improvising a melody for a distressed child, or a sleepy one, uttering no more words than "la-la-la." "Bye" is an old word meaning "sleep" and the word may actually have originated as a contraction of the saying "god be with ye" (Daiken, 1959).

Lullabies may be particularly effective because in general they combine the benefits of the female voice in a simply orchestrated format. All lullabies have the same characteristics: they are slow (about 60-82 beats per minute—about like a normal resting adult heartbeat). They are regular and monotonous, and repetitive; there are no exciting disruptions in rhythm and/or melody; and they are most effective when sung in a low voice. Research has shown that high pitches tend to create tension, or excitement, while lower pitches tend to promote relaxation. All these characteristics contribute to a baby's sense of security, safety and strength.

## **SETTING UP AN NICU MUSIC SYSTEM**

It is important to recognize that a music system should be designed so that it can be used efficiently, with minimum use of personnel time, and minimal need for upkeep of the components of the system. It would be optimal to include a music therapist in both the design and the use of the music system. However, it is recognized that playing music 24 hours a day to this patient population necessitates educating the NICU personnel in the intricacies of music therapy in this population. Neonatal nurses are extremely busy and if they will be responsible for deciding on music times it is best incorporated into their daily flowsheets, along with the charting for therapies and medications. Since the nurses are naturally somewhat preoccupied responding to critical situations, incorporating a simple box to check if music was played during the shift with room for specific comments will remind the neonatal nurse to think about music time. Initially, some of the neonatal nurses may not be sensitive to the benefits of NICU music, but with time most become very aware of the many benefits that the preemies receive from the music. Another option is to include the NICU physical

therapist or occupational therapist in on the music treatments and have them become advocates. It is helpful to put up a small poster at each bedside (perhaps attached to the CD player) with a succinct summary of the benefits of NICU music therapy. This helps to remind the nurses to play the music as well as developing interest from the parents of these babies.

Our neonatal music system at Piedmont Hospital in Atlanta, Georgia, has a dedicated CD music system at all 16 patient locations. The CD players, which sit on small wall mounted brackets, have CD carousels which accept our 5 common CD's which have the same order of CD's in each unit so the nurses know which CD they are playing each time. In addition, there is an individual slot for an extra CD if the parents wish to expose their child to music they have perhaps been exposed to prenatally. The CD players have a headphone output with a separate volume control. We use a small headphone plug to minijack adapter so we can plug in a self amplified computer speaker. The adapter also converts the stereo signal to a mono signal because we use only one of the 2 computer speakers. We have found that an inexpensive Labtec computer speaker system for under \$20 (model LCS-150) delivers clear sound and can be cleaned easily. The speaker sits between 3 and 10 inches from the baby's ear in the incubator or isollete. Sound levels are intermittently measured at the baby's ear with a battery operated Radio Shack digital sound level meter (cat. no. 33-2055, around \$50), so that approximate mean sound levels are 75 dB with peak levels of 80 dB. If sound levels are adjusted according to a baby's response to the music they are only decreased from these levels. In our unit we typically expose the smallest, most premature babies to womb sound music, and then advance to lullabies and simply orchestrated classical music. Some of the most unstable premature babies do not respond well to any kind of stimulation, including music. We are careful to monitor the behavioral and physiologic response these babies have with the music

and occasionally music is not initially played, or played at low volume, depending on the response.

In our unit, the neonatal nurses choose the timing, frequency and duration of music interventions, as well as which music selection is played. The following are some guidelines that the nurses use for the music interventions:

### **NICU MUSIC GUIDELINES for behavioral changes**

Consider the behavioral state when music is played.

Try not to disrupt the sleep state.

Use music to help change the behavioral state from agitation or fussiness and move towards one of quiet alertness or sleep state.

Play the music for the transition into minimal stimulation time.

### **NICU MUSIC GUIDELINES for desirable physiologic changes**

Increase in oxygen saturation

Decrease in heart rate

Mild decrease in blood pressure

The following are some of the titles that have been used in NICU music studies. Please note that studies have not been done to compare the relative effectiveness of any of these titles.

### **Lullabies**

A Child's Celebration of Lullaby (Music for Little People)

A Child's Gift of Lullabies (Someday Baby)

Dream a Little Dream (Transitions Music)

Lullaby Berceuse (Music for Little People)

Lullaby Magic (BMG/Discovery Music)

Lullaby Magic 2 (BMG/Discovery Music)

MusicBabies (MMB Music)

The Rock-A-Bye Collection (Someday Baby )

### **Classical Music**

Adagio-Karajan (PolyGram Records)

Mozart for Babies (Perleberg Music)

Perchance to Dream, Carol Rosenberger (Delos International)

### **Womb Sound and Heart Beat Music**

Baby Go To Sleep 1 (Audio- Therapy Innovations)

Baby Go To Sleep 2 (Audio- Therapy Innovations)

Transitions 1 (Transitions Music)

Transitions 2 Music to Help Baby Sleep (Transitions Music)

Womb Sound Classics for the New Arrival (Perleberg Music)

# Baby's Mother's Voice

Spoken word and singing

## SUMMARY

With a relatively small expenditure for music in our neonatal ICU's we can decrease the time in the NICU by over 3 days and save between 2,000 and 6,000 US dollars for every premature baby. The initial cost of music system hardware for each NICU patient area is recouped by a corresponding decrease in medical cost of care within several weeks. Not only are there medical and economic advantages from this type of intervention. There is no doubt that music transfers love and other emotions as well as wisdom and this conveys long term developmental benefits which will allow our little patients to approach their full potential as human beings.

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