MUSIC, STRESS REDUCTION AND MEDICAL COST SAVINGS IN THE NEONATAL INTENSIVE CARE UNIT

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Aim of Investigation

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.

A number of studies that have shown that music therapy is helpful in decreasing stress, increasing weight gain, and decreasing length of hospital stay in these babies. Other studies have shown that by using music or decreasing NICU sound levels, neonatal blood oxygen levels would increase. Despite this information, there has not been

widespread incorporation of music therapy in the care of babies in the NICU environment.. At the beginning of 1998, Piedmont Hospital instituted music therapy in all 16 patient areas in the neonatal ICU's. The aim of this study is to analyze any changes in weight gain, head circumference, need for respiratory support, and length of hospital stay after music therapy was instituted as well as to analyze any economic benefits. The effect of music exposure on brain growth and these implications are also examined.

Discussion

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). 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. 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. Many NICU's have instituted aspects of developmental care into their NICU nursing care. Piedmont Hospital incorporated developmental care into NICU care in 1995 and there were significant cost savings associated with this change. Prior to January 19, 1998 there was minimal use of music with Piedmont's NICU babies. At this point music therapy was instituted for all NICU babies.

Patients and Methods

The study was conducted at Piedmont Hospital in Atlanta, GA in a 16 bed NICU, with a 100% inborn population. The aim of this study was to look retrospectively at the babies admitted to the NICU on or after September 1, 1997 and discharged prior to the institution of music therapy on January 19, 1998 and compare them with a group of babies

exposed to the music intervention admitted on or after January 19, 1998 and discharged prior to April 19, 1998.

All patients from the above groups met the following criteria: (1) inborn, without transfer to another facility; (2) birth weight less that 2500 gms; (3) absence of chromosomal or other major genetic anomalies, congenital infections and congenital hearing problems; (4) no intraventricular hemorrhage (IVH) noted on cranial ultrasound; and (5) no surgical interventions. The demographics of our music group matched very closely with the non-music group as far as gestational age, birth weight and head circumference (HC), and APGAR scores (Table 1).

Table 1

Experimental Intervention

Compact disc players were installed at all 16 NICU locations. The headphone output of each CD player was connected to deliver a monophonic signal to individual mini-speakers which were located in each infant incubator or isolette, about 10 inches from the infant's head. The NICU nurses were inserviced on how to use the music system, and the sound levels at the infants' ears were measured with a sound level meter prior to starting music. The volume was adjusted so that approximate mean sound levels using a hand held sound meter so that mean sound levels were about 75 dB with peak levels no higher than 80 dB.

As all of the NICU nurses were already trained in developmental care the use of music was individualized for each baby incorporating the following guidelines with their developmental care:

Consider the behavioral state of the baby when the music is played. Try not to disrupt the sleep state. Use music to help change the behavioral sate from agitation or fussiness and move towards one of quiet

alertness or sleep state. Play the music for the transition into minimal stimulation time.

The following physiological changes are desirable effects from the music: increase in oxygen saturation, decrease in heart rate. If infant has been in a stimulated state with a high degree of sympathetic tone causing increased blood pressure and heart rate, then a mild decrease in blood pressure as well as heart rate in response to the music is desirable.

The numbered CD selections in each of the carousel CD players was the same. CD 1 and 2 were soft womb sounds with female vocal sounds, CD 3 and 4 were lullabies, and CD 5 simple Mozart arrangements. The following titles were used (1) Transitions (Transitions Music, 1987), (2) Transitions 2 Music to Help Baby Sleep (Transitions Music, 1990), (3) Dream a Little Dream (Transitions Music, 1992), (4) Lullaby Berceuse (Music for Little People, 1986), (5) Mozart for Babies (Blue Sky Entertainment, 1995). The first 2 selections were womb sound music, the next 2 were gentle lullabies, and the last a collection of simply orchestrated Mozart pieces. A single CD slot on each CD player was available if a parent wanted to expose their infant to a music selection they had been exposed to prenatally.

The NICU nurses were allowed total discretion in choosing the timing, frequency and duration of the music interventions as well as the choice of music selection from the CD players. In clinical practice practice it became clear the the nurses used the womb sound/female vocal sound recordings for the most premature, low birth weight infants, and the lullabies and Mozart for the more mature NICU patients. The timing and frequency of music was directed by the NICU nurses using their own clinical judgement within the parameters of developmental guidelines. The nurses were given instructions to try to play some music each 8 hour shift; however in reality the nurses were occasionally overwhelmed and did not always play the music during each shift. Some of the most

unstable, premature, very low birth weight babies did not initially receive much music either because they did not respond well to any form of stimulation or the nurses were extremely busy with other priorities. Within their hospital stay, all of these unstable, very low birth weight babies were eventually introduced to more frequent music interventions.

Background

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 & Roeder, 1997). This explains the striking correlation between the IQ's of twins, especially those of adult twins raised apart. There is no doubt that intrauterine auditory stimuli contribute a large part to the environment of the fetus.

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 & Hepper, 1992). 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 & Abrams, 1996). This is about as loud as it gets on a

crowded dance floor on a Saturday night. A good deal of attention has been given to the so called "Mozart Effect" where exposure to this music increased spatial IQ in college students (Rauscher, Shaw & Ky, 1995), as well as work with preschool children which showed that music training can enhance language development, spatial and mathematical abilities (Rauscher, et al, 1997). Evidence points to the fact that similar learning benefits extend far 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 & 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 that can accessed and used by the fetus in many deep, profound ways (Schwartz, 1997). 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. 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^{nd} and 3^{rd} trimester auditory amphitheater that is perhaps more important that 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.

It seems logical that the early loss of the intrauterine sound

environment would effect 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). It would be a tremendous benefit for the premature baby if music could help brain size and cognitive abilities catch up.

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 & 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 & Traversay, 1995). They had higher oxygen saturations and more time in the sleep state compared to a control group. Several other studies have shown a doubled daily weight gain when premature babies in the NICU were exposed to music therapy (Coleman, Pratt, et.al., 1998, Caine, 1991). Additional studies using music with premature babies have shown a 3

to 5 day earlier discharge from the NICU (Caine, 1991, Coleman, Pratt & Abel, 1996, Standley, 1996).

Results

Our initial pilot study compared a group of our NICU babies during the time period before the music system was instituted, with a group of babies once the music system was in place. The demographics of our music group matched very closely with the non-music group as far as gestational age, birth weight, head circumference (HC) and APGAR scores. Our sample size was not large enough to reach statistical significance. A comparison of means between the music and non-music groups were similar to previous studies and showed:

$6,891 less hospital charges/infant in music group (Table 2).

Table 2

3.1 days/infant faster discharge in music group (Table 3).

Table 3

$1,706 less respiratory therapy charges/infant (separate from hospital charges) in music group (Table 4).

Table 4

A growth curve analysis showed a trend for faster growth in head circumference (HC) in the group of babies exposed to music (Figure 1).

Figure 1

Growth curve analysis showed no trend for faster weight gain in the music group (Figure 2).

Figure 2

None of the babies showed any sign of hearing deficit on discharge from the NICU as measured by brainstem auditory evoked response testing (BAER).

We had intended to continue comparing the results between our ongoing NICU music population with the previous non-music group babies. However, the demographics of our NICU population began to change, with an increase in very low birth weight babies. Since the NICU was doing such a good job in salvaging the lowest birth weight babies, the obstetricians' increased efforts to stop threatened preterm deliveries below 24 weeks gestation began bringing more potentially salvageable 24 and 25 weeks gestation babies to our NICU. In addition, the advent of high frequency oscillatory ventilation introduced a new modality into our NICU which would have a positive effect on only the music group babies. We could not have set up an ongoing non-music control group at this point since ethically it would have been difficult to withhold music since it had become our standard of care.

Conclusions

Despite our small sample size, the benefits of incorporating music into our NICU care were consistent with previous studies showing faster discharge from the NICU and decreased hospital charges with music. We did not find any trend for increases in weight gain in our music babies. Previous studies have been inconsistent in regard to weight gain changes with music (Standley, 1996). An apparent trend for faster growth in head circumference with music has implications for a possible effect of music on prenatal and newborn brain growth. In our institution the initial cost of music system hardware was recouped by a corresponding decrease in medical cost of care within two weeks. It appears that 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 9,000 US dollars for every premature baby.

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