

Original Research Article

The effect of ladder approach on development of preterm low birth weight infants with HIE-2

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Received: 20 October 2019

Revised: 07 January 2020

Accepted: 27 January 2020

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ABSTRACT

Background: Premature infants with Peri-natal asphyxia leading to a hypoxic-ischemic encephalopathy (HIE) are at greater risk for cerebral palsy. HIE grade II infants have long term neurological complications due to maladaptive brain wiring during NICU stay. Ladder approach, with graded stimulation program is administered by Occupational therapist, plays a vital role to minimize the maladaptive responses to environment. Objective of this study was to effect of Ladder Approach on preterm low birth weight Infants with HIE-2 as compared to conventional treatment. Design of this study was to Prospective Block Randomized Convenient Sampling Control Trial, Experimental design study. The study was carried out in the NICU and PU ward of Tertiary care hospital in metropolitan city from April 2015 to October 2016. The study subjects included a convenient sample of 30 preterm Low birth weight HIE-2 infants randomly selected into study or control groups. Neonatal behavioural Assessment scale (NBAS), Infant Neurological International Battery (INFANIB).

Methods: The preterm infants from study group who received Ladder Approach and control group who received routine conventional care only. Outcome measures NBAS was at baseline and first follow up. INFANIB was administered at second follow up to assess neurodevelopment.

Results: Showed that the premature infants of the study had significant difference in neuro behavioral status with mean for all subcomponents from to post intervention mean 39.6 in experimental group and from baseline mean of 24.3 to post intervention mean score of 33.2 in control group on neurobehavioral scale. Further neurodevelopmental status showed similar results on INFANIB in experimental group.

Conclusions: The premature Infants with HIE grade 2, receiving ladder approach have shown more mature responses resulting into well-organized Neurobehavioral status, and resulted in improved brain wiring as evident in INFANIB.

Keywords: Brain, HIE-2, Neurodevelopment, Neurobehavioral status, Premature infant

INTRODUCTION

Preterm birth, also known as premature birth, is the birth of a baby at less than 37 weeks gestational age. Gestational age (or menstrual age) is a measure of the age of a pregnancy where the origin from woman's last normal menstrual period (LMP). A normal pregnancy lasts between 38 and 42 weeks. Preterm infants usually

show physical signs of prematurity in reverse proportion to the gestational age. As a result, they are at risk for numerous medical problems affecting different organ systems. Premature infants are at greater risk for cerebral palsy, developmental delay, hearing problems, and problems seeing.

These risks are greater the earlier a baby is born.^{1,2}

Hypoxic-ischaemic encephalopathy (HIE) is caused by severe or persistent birth asphyxia in infants. It can result in death or hypoxic-ischaemic brain injury presenting as encephalopathy in the early neonatal period.^{3,4}

Hypoxic-ischaemic encephalopathy is the abnormal behavioural state that can be seen in an infant in the early neonatal period. During a perinatal hospitalization a study in Nepal found that 94% of infants diagnosed with HIE presented with tone abnormalities, sucking ability was poor in 32% and 19% presented with problems with consciousness.⁵ The condition is associated with long term delayed developmental outcomes and is more prevalent in developing countries.⁵ Infants that survive present with different severities and the condition often leads to severe neurological impairment resulting in cerebral palsy.⁴ Previous follow up studies have shown the children with mild encephalopathy or HIE I are likely to be free of disability but those with moderate encephalopathy HIE II have a disability rate up to 25% with both neurological and developmental dysfunction. The majority of infants presenting with severe encephalopathy or HIE III usually have multiple disabilities.⁵ Infants with HIE II and III are therefore referred for rehabilitation and occupational therapy which provide intervention for these children.^{5,6}

The wiring of the brain is occurring when the infant is in NICU it is the vital time to promote adaptive versus maladaptive wiring. Thus, it is important to create adaptive responses versus maladaptive responses to their environment as they grow and develop into children and adult. With recent advancement in healthcare, succeeding in keeping the infant alive is no longer acceptable.⁵ Occupational therapy plays a vital role to minimize the maladaptive responses to environment.

Ladder approach is one of the new intervention approaches developed by Lisa Bader, based on Newborn Individualized Developmental Care and Assessment Program (NIDCAP) which leads guideline to plan effective intervention.

Occupational therapy plays a vital role to minimize the maladaptive responses to environment. Conventionally various techniques such as therapeutic positioning, therapeutic handling, tactile stimulations, sound modifications, visual stimulations, Kangaroo mother care are the various techniques used by Occupational therapists.

Newborn individualized development care and assessment program (NIDCAP) is a program developed by Neonatology team, the NIDCAP Federation International, -Using detailed observational tool, often referred to as the NIDCAP observation, the infant's behaviors can be interpreted as steady and relaxed or as representing stress or discomfort by observing and then interpreting behaviors of infants within their environment and as reactions to care they receive, developmental care

plans can be developed, with the caregiving team, that best support's the infant's overall goals and efforts at self-regulation Research demonstrates that NIDCAP improves brain development, functional competence, health, and life quality. NIDCAP program leads guideline to plan effective Occupational therapy intervention.⁷

Ladder Approach Is an innovative and structured way to deliver therapy services in the Neonatal Intensive Care Unit based on the concept of NIDCAP. It allows therapist to deliver treatment according to sensory system development in a unimodal approach (until ready for multimodal stimulation) and at the right time in the infant's development.⁸ The sensory/perceptual systems develops in the following developmental sequence: Somatosensory (tactile and proprioceptive), vestibular, chemoreceptive (taste and smell), auditory and visual.⁹ The ladder approach follows the same pattern or sequence while treating the infants in NICU.¹⁰

Aim of this study was to the effect of Ladder Approach on preterm low birth weight Infants with HIE-2 as compared to conventional treatment.

Objectives of this study was to assess the effect of Ladder Approach on the neurobehavioral and neurodevelopmental status of preterm low birth weight infants with HIE-2 admitted in NICU.

To develop graded intervention approach for preterm low birth weight infants with HIE-2 for minimizing maladaptive wiring in the brain during NICU stay.

METHODS

Prospective Block Randomized Convenient Sampling Control Trial, Experimental design, A-B design study was carried out in the NICU and PU ward of the tertiary care hospital for the duration of September 2015 to October 2016. The study was approved by the Institutional Ethics Committee on 27th March 2015. Informed consent was obtained from the parents of infants included in the study. Infants satisfying the following inclusion criteria were included in the study

Inclusion criteria

- Age: 30weeks -32weeks of gestational age
- Diagnosed as Hypoxic Ischemic Encephalopathy grade 2
- Infant with birth weight between 1000 gms -2000 gms.

Exclusion criteria

- Unstable cardinal parameters
- Unstable Vitals
- Deaf and Blind
- Congenital anomalies

Assessment tools

The Neonatal Behavioral assessment scale (NBAS), Infant Neurological International Battery (INFANIB), Infants were assigned in control group and experimental group using Block randomization.

Infants in control group received conventional treatment such as

Developmental care

It is an inclusive term applied to environmental modifications, changes in caregiving practices, and efforts to increase family involvement.¹¹

Therapeutic positioning

External supports were provided, to maintain flexed midline-oriented posture of the immature infants. Positioning was done as per neuromotor developmental intervention to minimize positional deformities and to improve muscle tone, postural alignment, movement patterns,

Non-nutritive sucking

NNS used as a self-soothing activity.

Kangaroo care

Mothers were advised to take infant in the Kangaroo bag at least for four hours per day.

Infants in experimental group received treatment using LADDER approach¹⁰

The ladder proceeds up from bottom to up in the following manner as follows:

Initially treatment was started with unimodal stimulations given in hierarchy as follows

Tactile/proprioceptive

Myofascial release, positive proprioceptive feedback and infant massage.

Vestibular

Tummy time, therapeutic ball activities

Olfactory/gustatory

Oromotor stimulations with the therapist's finger dipped in mother's milk.

Auditory

Soft music toys.

Visual

Humans face very brief moments. Goal setting and treatment planning were done using the ladder approach. Treatment proceeded from unimodal to multimodal stimulation later. Infants from both the group received therapy for 15 min every day for first 15 days or till infant graduated from NICU. Post discharge it was followed by one intervention session by the therapist per week till infant reached term age of eight weeks.

The parents were also given Home program to be followed for once a day after discharge from the hospital. First follow up was taken at the term age of 4 weeks and second follow up at the term age of 8 weeks.

The Neonatal Behavioral assessment scale (NBAS) was used as outcome measure at baseline and during first follow up.¹² NBAS can be used only for 28 days of termed age.

Later Infant Neurological International Battery (INFANIB) was used to assess neurodevelopmental status later at second follow up. INFANIB consists of assessment of posture, extremity and axial tone, primitive reflexes and postural reactions.¹³

The data was entered using MS-Excel-2007 and analyzed using SPSS-16 software.

Following statistical tests of significance are used:

- Kolmogorov Smirnov test - To check the distribution of data (Normal or Non normal)
- Un-paired t test - For comparison of mean between two groups (Numerical data which is normally distributed)
- Repeated measures ANOVA test - for comparison within group (For comparison of mean of variable recorded Baseline, first follow up and second follow up)
- Bonferroni test - is used for post hoc comparison i.e. Baseline with first follow up and second follow up within the group.

The p value less than 0.05 at 95% confidence interval was taken as statistically significant results.

- Group 1- Experimental group (Ladder approach) -15 subjects.
- Group 2- Control Group (Conventional treatment)-15 subjects.

RESULTS

As seen in the Table 1, both the groups match on the basis of gestational age and birth weight, as there is no significant difference in their age and birth weight.

Thus, both the groups are matched groups.

Table 1: The mean values of gestational age and birth weight of both the groups.

Group	N	Mean	Standard deviation	p value	Significance
Gestational age					
Experimental	15	31.1	0.9	0.548	Not significant
Control	15	30.9	0.9		
Birth weight					
Experimental	15	1422	192.3	0.884	Not significant
Control	15	1408.2	193.1		

p'sig if ≤0.05

Table 2: The comparison between experimental group and control group during baseline and follow up on neurobehavioral assessment scale components.

Component	Group	N	Mean	Std. deviation	p value	Significance	
Habituation	Baseline	Experimental	15	4.2	1.0	0.458	Not significant
		Control	15	4.4	0.6		
	Follow up	Experimental	12	6.9	0.7	0.198	Not significant
		Control	13	6.5	0.7		
Social interactive	Baseline	Experimental	15	3.8	1.0	0.779	Not significant
		Control	15	3.9	0.7		
	Follow up	Experimental	12	6.6	0.4	0.024	Significant
		Control	13	6.1	0.6		
Motor system	Baseline	Experimental	15	4.2	0.5	0.372	Not significant
		Control	15	4.4	0.8		
	Follow up	Experimental	12	6.3	0.4	0.005	Significant
		Control	13	5.7	0.6		
State organisation	Baseline	Experimental	15	4.5	0.7	0.350	Not significant
		Control	15	4.8	0.9		
	Follow up	Experimental	12	6.9	0.5	<0.001	Significant
		Control	13	5.3	0.9		
Autonomic system	Baseline	Experimental	15	4	0.01	0.890	Not significant
		Control	15	3.9	0.02		
	Followup	Experimental	12	6.3	0.5	<0.001	Significant 0.198
		Control	13	5.7	0.6		

Unpaired t test (p significant if ≤0.05)

Table 3: Comparison between experimental group and control group INFANIB scores during follow ups.

INFANIB	Group	N	Mean	Standard deviation	p value	Significance
Baseline	Experimental	15	54.7	4.0	0.303	Not Significant
	Control	15	53.1	4.7		
First Follow up	Experimental	15	62.3	3.5	< 0.001	Significant
	Control	15	53.9	4.8		
Second Follow up	Experimental	15	69.00	2.6	< 0.001	Significant
	Control	15	57.5	5.1		

Then data was compared to analyse the effect of the intervention on various components of NBAS at different follow ups (Table 1). The table two shows that all subcomponents showed significant difference between experimental group and control group in post-intervention scores except in habituation. When Social interactive component scores were compared between the control and experimental group as seen in table two, the experimental group showed significantly high scores (C I

3.3 -4.3 to CI6.4 -6.6) than pre and post intervention scores in control group (C I 3.4-4.3 to C I 5.7 -6.5).

The Experimental group showed significant improvement (CI 3.95-4.45 to 6.1-6.5) in the motor system than Control group (CI 4-4.8 to 5.37-6.03) at the end of eighth week. State organisation of infants in Experimental group has shown steep rise with (CI 4.15 - 4.85 to CI 6.62 -

7.18). The autonomic system regulation did show a steep rise in experimental group on follow up.

The study also intended to analyse the effect of ladder approach on neurodevelopmental status of preterm HIE II infants.

Then the data was analysed to observe neuro developmental status of the infant during follow ups using INFANIB (Table 2).

When it was analysed using INFANIB as seen in table three, the experimental group showed significant difference (CI 54.7-56.7 to 67.5-70.5) as compared to control group (CI 50.5 - 55.7 to 54.75 - 60.25) in the INFANIB score during the last follow up.

The data was also analysed using the graph (Table 3).

As seen in graph one INFANIB score showed steep hike at the end of second follow up showing near normal neuromotor development approaching score of 69. INFANIB Score is normal if greater than 72 at age between 4 months to 8 months. The second follow up was taken at six months. Thus, it showed good carry over effect on experimental group, which received LADDER approach intervention (Figure 1).

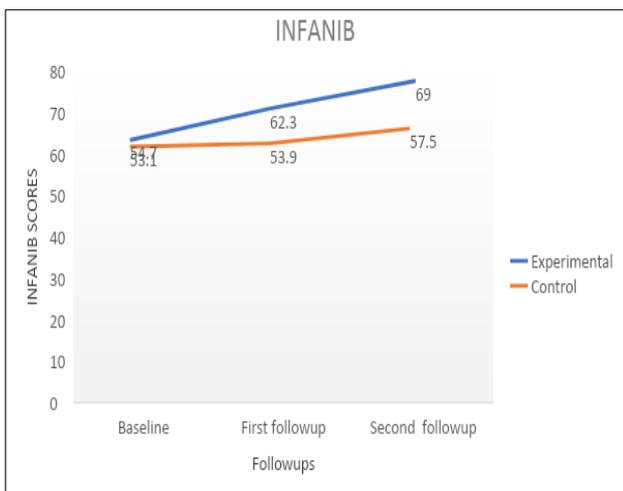


Figure 1: Improvement on INFANIB score in both the groups.

DISCUSSION

Based on the recent updates on developmental care interventions of preterm very low birth weight infants, LADDER approach was used in experimental group subjects in the present study and other group received conventional approach.

All the infants were diagnosed as HIE grade II and did not have any other complications. Brazilton Neuro behavioural Assessment Scale (NBAS) was administered on these infants pre and Post intervention to analyse

Neurobehavioral status of these infants. Both the groups were matched at the baseline in all the subcomponents of NBAS.

Both the interventions showed significant improvement in Habituation scores. Habituation is an aspect of learning in which repeated presentations of a stimulus result in decreased responsiveness. When an infant is placed in an otherwise homogeneous environment and shown a visual stimulus the stimulus will initially attract the infant's attention, but as time passes the infant's attention will wane (as measured by reduced looking). Habituation refers to this decrement in visual attention and measures of this decrement reflect memory formation (of the now familiar stimulus), and therefore the processing of information from the stimulus, and can be considered as an indication of infants' ability to inhibit attention to the familiar stimulus.¹⁴

In the present study experimental groups received multi-sensory stimulations as per the readiness to respond to stimulus. In the present study the negative effect of separation in NICU from parents, have been minimised with intermittent containment hold by the therapist or by caregiver (Mother) and positive touch while using ladder approach, which also emphasized use of these approaches by mothers during painful events like taking a prick for the infant while in NICU. Babies have an innate need to be loved and nurtured and develop trust and attachment. The article on need of positive touch have emphasized on effect of positive human touch on wellbeing of infants, when babies are in sub optimal conditions.¹⁵ This has enhanced the social interactive skills in the experimental group.

Infants in both the groups received multisensory stimulations during intervention, where as in LADDER approach the infants were initially given Unimodal and then multimodal stimulations, depending on their ability to tolerate sensory stimulations. It was observed that the infants from experimental groups showed better motor system organization in the environment than infants from control groups. Results seen in the study are in accordance with the study of multisensory stimulation in preterm infant. In the said study the researcher observed that Multisensory stimulation appears to have a beneficial effect on the tonal maturation in preterm infants.¹⁶ The multimodal stimulations have also shown good response on Motor system as well.

This has resulted in mature responses from motor system. Ladder approach starts with containment hold, emphasizes on Positive touch in initiation of treatment and emphasizes on Ladder approach used in experimental group, which insists on Tummy time as good vestibular input may have done the difference same as in the article published by NIH, they have stated that Tummy Time is important because it makes neck and shoulder muscles stronger so your baby can start to sit up, crawl, and walk.¹⁷ Positive touch and massage was used as

proprioceptive input in present study has beneficial effect. As stated in review article by Anjali Kulkarni et al, it is stated that massage has several positive effects in terms of weight gain, better sleep-wake pattern, enhance neuromotor development, better emotional bonding, reduce rates of nosocomial infection and thereby, reduce mortality in the hospitalized patients.¹⁸

The State Organisation in infants, experimental group showed significant improvement in all the follow ups. Ladder approach is based on Al's synactive theory, it is stated that graded sensory stimulation given to the infants, can lead to better state organization.¹⁰ Rocking, use of soft music used in intervention of experimental group has enhanced state organization. Review of different studies on the effect of Music on High risk premature babies stated that Both nurses and parents reported that music could decrease stress in the premature infant. The introduction of music to intubated, premature infants who are agitated may improve the clinical status of the infant.

Music intervention may be useful when infants are inconsolable and other nursing interventions have failed to pacify the distress infant.¹⁸

Self-Regulation which leads to good state organization showed significant difference in scores post intervention in both the groups as seen in table two. As per synactive theory, observable strategies the infant uses (Self-Regulation) in maintaining a balanced, relatively stable and relaxed state of subsystem of functioning or in returning to this a state of subsystem functioning if imbalance, or stress has occurred within the subsystems. An additional component of the regulatory subsystem is observable in the kind and amount of support offered by the caregiver (e.g., supporting a soft, tucked, flexed position of the infant's arms and legs) or by the environment (e.g., dimming the lights in the nursery or using a cover on the islet).¹⁹ In present study intervention included facilitatory tuck and swaddling by therapist as well as caregivers leading to regulation of subsystems.

Both the groups got support from care givers and proper positioning. This may have helped in self-regulation of infants in both the groups.²⁰

Autonomic system considers: the basic physiologic functioning of our body necessary for survival; includes heart rate, respiratory rate, blood pressure, skin color, tremors/startles, body temperature, GI functioning. Graded sensory stimulations used in Containment hold, education for proper handling techniques, vestibular stimulations were given in both the groups, this has given good results in regulating autonomic system. Use of graded vestibular, olfactory, visual and auditory system is necessary for regulation of autonomic functions. stimulation through the senses of touch, hearing, seeing, smelling, and tasting directly affect the sensory neurons and help in establishing these connections. In one of the

studies to observe the effect of olfactory stimulation on preterm infants it is stated that the introduction of a pleasant odor in the incubator is of therapeutic value in the treatment of apneas.²¹

The study also intended to analyse the effect of ladder approach on neurodevelopmental status of preterm HIE II infants. Multimodal stimulations were used at higher rungs of ladder in experimental group.

In the review on multi-sensory integration and child neuro development early integration approach has been analyzed. According to the Early Integration Approach, the nervous system is multisensorial right from its early development stage, possessing the capacities to detect redundant aspects of the surrounding environment. Thus, early use of multisensory stimulations can lead to appropriate neurodevelopment this explains the results in present study.²²

The present study is an effort to analyze effect of graded stimulation through LADDER approach on preterm infants, with HIE grade II, who are at the higher risk of delayed neurodevelopment. The results are very positive, though there are some limitations of this study. The study is single blinded study, the investigators could not be blinded for the study. Socio culture economical background of the parents of infants was not considered in the study, which may have differed and resulted into different social stimulations. As intervention was expected to be continued by caregivers after discharge of the infant. Compliance of mother/caregiver could not be assured. Infants were observed for short duration. Long follow up may be recommended. Mental quotient is not been addressed during follow up. The study can be replicated on premature infants with the different comorbidities.

CONCLUSION

The in-utero early sensory experiences of the fetus are essential for normal brain development during the perinatal period. The premature infant (considered as extra-uterine fetus) is deprived of in-utero sensory experiences. These infants are exposed to unusual sensory stimuli in the Neonatal Intensive Care Units (NICU). These experiences can have detrimental effects to the developing brain in terms of adverse neurodevelopmental outcomes.

The Ladder approach is the systemic program to administer unimodal sensory stimulation to gradually administering multimodal sensory stimulations and complex stimulations. This has enhanced more mature responses from the central nervous system and resulted in organized Neurobehavioral status, leading to better neurodevelopment. Ladder approach can be accepted for better outcomes in neurodevelopmental status of infants. The results can be confirmed by doing multicentred studies and by maintaining long term follow ups.

Funding: No funding sources

Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee of LTMMC and GH, Sion Mumbai, India

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Cite this article as: Jadhav TR, Jaywant SS. The effect of ladder approach on development of preterm low birth weight infants with HIE-2. *Int J Contemp Pediatr* 2020;7:520-6.