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Comparison of motor development of low birth weight (LBW) infants with and without using mechanical ventilation and normal birth weight infants

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Abstract

Background: To determine whether using mechanical ventilation in neonatal intensive care unit (NICU) influences motor development of low birth weight (LBW) infants and to compare their motor development with normal birth weight (NBW) infants at the age of 8 to 12 months using Peabody Developmental Motor Scale 2 (PDMS-2).

Methods: This cross sectional study was conducted on 70 LBW infants in two groups, mechanical ventilation (MV) group, n=35 and without mechanical ventilation (WMV) group, n=35 and 40 healthy NBW infants matched with LBW group for age. Motor quotients were determined using PDMS-2 and compared in all groups using ANOVA statistical method and SPSS version 17.

Results: Comparison of the mean developmental motor quotient (DMQ) of both MV and WMV groups showed significant differences with NBW group ($p< 0.05$). Also, significant difference was found between the gross DMQ of MV group and WMV group ($p< 0.05$). Moreover, in MV group, both gross and fine motor quotients were considered as below average (16.12%). In WMV group, the gross motor quotient was considered as average (49.51%) and the fine motor quotient was considered as below average (16.12%).

Conclusion: It seems that LBW infants have poor fine motor outcomes. The gross motor outcomes, on the other hand, will be significantly more influenced by using mechanical ventilation. In addition, more differences seem to be related to lower birth weight. Very Low Birth Weight (VLBW) infants are more prone to developmental difficulties than LBW infants with the history of using mechanical ventilation especially in fine motor development.

Keywords: LBW infants, Mechanical ventilation, Motor development, Peabody Developmental Motor Scale -2 (PDMS-2).

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Introduction

Advances in medical care and neonatal medicine have led to changes in survival pattern of high risk neonates (1). One of the complications that have been found in these high risk neonates is LBW (< 2500 grams). According to World Health Organization (WHO) statistics, the rate of LBW is 17% worldwide (6% in developed countries and 21% in developing countries). Studies revealed that the rate of LBW is 10% in Iran (2); and 8.4 % in Yazd, a city in the center of Iran (3).

One of the most common neonatal complications of prematurity and LBW is respiratory failures like Respiratory Distress Syndrome (RDS) which often needs using mechanical ventilation (MV) for improving the neonatal survival, especially for premature neonates born less than 30 weeks gestation with immature lung function (4). Studies showed that MV in LBW neonates,

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and especially Extremely Low Birth Weight (ELBW), is linked to poor neurodevelopmental outcomes (5). These risk factors increase with increased duration of MV (6).

Although the main proportions of LBW neonates are born in developing countries (2), the majority of studies on developmental outcomes of prematurity have been performed in developed countries. Considering the effects of different cultures and socioeconomic status on development and the importance of conducting developmental evaluations in developing countries, close attention should be paid to such kinds of studies in these countries. The evidence could be applied in future developmental intervention planning.

In Iran, there has been lack of research evidence about developmental outcomes of more complicated LBW neonates like neonates which used MV. In this study we prospectively investigated the development of gross and fine motor skills in infants with the history of LBW and over 14 days use of MV. The aim of this study was to compare gross and fine motor development of infants with the history of LBW with MV and without MV (WMV) over 14 days and healthy NBW infants with 8 to 12 months of age using Peabody Developmental Motor Scale-2 (PDMS-2).

Methods

Data

This descriptive, prospective and cross sectional study was carried out in the occupational therapy clinic of Aliasghar Hospital, Tehran, Iran. The study was conducted on three groups of infants aged 8 to 12 months (all mentioned ages for LBW infants are corrected for prematurity) as follows: LBW group, birth weight <2500g, in form of MV and WMV groups and with normal birth weight (NBW) group. The sample size based on random sampling method was calculated to be 35 infants included 35 infants with the history of LBW using MV over 14 days (n=35), 35 infants with the history of LBW and WMV (n=35) and 40 healthy NBW infants (n=40).

MV group consisted of infants with corrected age of 8 to 12 months admitted to NICU of Aliasghar Hospital who used MV for 14 days or more. The inclusion criteria were: 1. Birth weight of less than 2500 grams. 2. Using MV for 14 days or more after third days of birth with diagnosis of respiratory failures, pCO_2 more than 60 mmHg, pO_2 less than 50 mmHg and pH less than 7.20. 3. Single tone infant.

WMV group consisted of all infants with corrected age of 8 to 12 months who admitted to Neonatal Intensive Care Unit (NICU) of Aliasghar Hospital for 14 days or more. The inclusion criteria were: 1. Birth weight less than 2500 grams. 2. Not using of MV 3. Being single tone.

The data for LBW infants were obtained from neonatal files of infants in NICU. For NBW group, all infants aged 8 to 12 months referred to healthcare center of Aliasghar Hospital for vaccination were screened for eligibility to the study.

Exclusion criteria were: 1. Any brain injury like intraventricular hemorrhage (IVH) or seizure, genetic disease, degenerative disease and /or other acquired problems which affect the development after discharge of NICU. 2. Any congenital abnormalities affecting the development. 3. Any sensory problem like deafness and/or blindness.

In this study because of our excluded criteria on any prenatal or perinatal brain complications we included all infants regardless of kind of delivery. Also, because of not having access to all Apgar scores we included infants regardless of their Apgar scores. Moreover, because of the methodology of our study which was prospective we could not completely monitor any complications that might be happened during intubation. However, a regular suctioning and tube control were mentioned for all MV group infants during intubation in their neonatal files.

All infants were visited by a pediatrician for clinical and neurological examinations and if they fulfilled the above criteria were enrolled in the study.

After screening and selecting all groups randomly, the informed consent form was given to their family and then the questionnaire containing medical and developmental history and demographic information of infants were completed by examiners. Finally two occupational therapists blinded to the history of infants conducted PDMS -2 for each infant. Assessments were performed in the occupational therapy clinic and infants were examined individually.

The PDMS-2 is one of the most commonly-used assessments for measuring motor skills of infants and toddlers from birth through age 5. For children with special needs, the PDMS-2 is one of the most reliable testing instruments used by many professionals as a diagnostic tool for assessing of gross and fine motor skills. It has been used in a number of follow-up studies investigating motor skills in the preterm population. (7-9). With the PDMS-2, most dysfunctions of motor skills will be identified. Using the results of the PDMS-2, we can develop a more responsive learning and remediation program for the child with special needs. This test is composed of six subtests that assess related motor abilities that develop early in life: reflexes, stationary (body control and equilibrium), and locomotion, object manipulation, grasping, and visual-motor integration. Results from these subtests are used to generate the three composite scores: gross motor quotient, fine motor quotient, and total motor quotient with a mean of 100 and a standard deviation of 15 (10).

Statistical Analysis

After collecting the perinatal variables and gross and fine motor scores, the motor quotients were determined and data were analyzed and compared using SPSS version 17. Mean motor quotients scores were compared using ANOVA. Spearman's correlation coefficient was used to examine the relationship between the mean of gross and fine motor quotients and qualitative variable and Pearson's correlation coefficient was used to examine the relationship between the mean of gross and fine motor quotients and quantitative variable. Differences were considered significant at p values of less than 0.05.

Results

Study population was 70 LBW infants (WMV group, n=35) and (MV group, n=35) and 40 healthy NBW infants (NBW group, n=40). The study comprised 23 males and 12 females in MV group, 19 males and 16 females in WMV group, and 18 males and 22 females in NBW group. Mean birth weight, gestational age and other perinatal characteristics of each group are summarized in Table 1. In this study we could not find any Extremely Low Birth Weight (ELBW) infant matching our inclusion criteria.

In relation to mean fine motor quotient, there were significant differences between MV and WMV in comparison with NBW group. But, the mean fine motor quotient in MV and WMV group showed no significant differences ($p<0.05$).

In relation to mean gross motor quotient, there were significant differences between

Table 1. Perinatal Descriptive statistics.

Variable	LBW, MV (n= 35)	LBW, WMV(n=35)	NBW(n= 40)
Gestational age, week (mean±sd)	30.4	30.2	-
Birth weight, g (mean±sd)	1410±355	1450±390	3080±410
Males (n (%))	23(65.71)	19(54.28)	18(45)
Length of stay in NICU (mean±sd)	64±3.0(49-81)	20± 2.4(14- 30)	-
Days Mech. Ventilation (mean±sd)	16.3±2.1	-	-
Given surfactant (%))	20(57.14)	-	-
Highest Pco2 (mean±sd, mmHg)	50.88(58.4)	-	-
Lowest Po2 (mean±sd, mmHg)	50.9±1.0	-	-
Lowest PH (mean±sd)	7.28±1.4 (7.08-7.45)	-	-
	7.28± 1.2(7.08-7.45)		

MV: with Mechanical Ventilation; WMV: without Mechanical Ventilation; NBW: normal birth weight

MV and WMV in comparison with NBW group. In addition, the mean fine motor quotient in MV and WMV group showed significant differences (p<0.05).

Finally, In relation to mean total motor quotient, there were significant differences between MV and WMV in comparison with NBW group and there were no significant differences between MV and WMV group, in terms of the mean total motor quotient (p<0.05).

Comparison of three groups (NBW and MV and WMV) based on mean gross, fine and total motor quotient in two sub groups (LBW, VLBW) is shown in Tables 2-4.

Moreover, based on the multiple comparisons by Tukey's HSD, statistically significant difference was found just in gross developmental motor quotient (DMQ) when the DMQs of MV group compared with that of WMV group (p< 0.05).

Furthermore according to the guide to interpreting PDMS-2 quotient scores in Peabody examiner's manual, the mean of all motor quotients in MV sub groups (LBW, VLBW) except for fine motor quotient of VLBW were in the range of 80-89. It means that motor development of all these groups except for fine motor of VLBW were below average (16.12%). The mean of fine motor quotient of VLBW was in the range of 70-79 that interpreted as poor (6.87%). On the other hand, in WMV group, the gross motor quotients of all sub groups (LBW, VLBW) like the NBW group, were in the range of 90-110 and considered as average (49.51%) and the fine motor development is in the range of

Table 2. Comparison of gross DMQ of MV, WMV and NBW groups.

Group	N	Gross Mean DMQ(sd)	p
NBW	40	107.45(9.18)	
MV			
Total MV	35	82.51(18.90)	0.003
LBW	7	86.07(17.69)	0.001
VLBW	28	82.93(19.85)	0.002
WMV			
Total WMV	35	91.71(14.23)	0.001
LBW	22	94.27(20.95)	0.002
VLBW	13	93.43(17.24)	0.000

Table 3. Comparison of fine DMQ of MV, WMV and NBW groups.

Group	N	Fine Mean DMQ(sd)	p
NBW	40	104.11(7.22)	
MV			
Total MV	35	83.33(21.15)	0.007
LBW	7	84.09(20.33)	0.005
VLBW	28	79.05(21.15)	0.001
WMV			
Total WMV	35	85.55(17.33)	0.000
LBW	22	88.77(21.91)	0.001
VLBW	13	83.45(19.44)	0.000

Table 4 .Comparison of total DMQ of MV, WMV and NBW groups.

Group	N	Fine Mean DMQ(SD)	p
NBW	40	106.77(8.29)	
MV			
Total MV	35	82.80(20.29)	0.002
LBW	7	85.39(18.47)	0.001
VLBW	28	82.29(21.24)	0.002
WMV			
Total WMV	35	84.59(18.29)	0.000
LBW	22	85.71(19.11)	0.002
VLBW	13	83.55(20.44)	0.001

80-89 and as a result, considered as below average (16.12%).

The results of this study also showed that there was no correlation between motor quotients and gestational age , sex , length of stay in NICU and days of mechanical ventilation in LBW group (p>0.05).

Discussion

This study pursued to characterize the motor quotients and compare the gross and fine motor development of LBW infants with and without using MV with NBW infants at the age of 8 to 12 months.

Recent studies showed that LBW infants are prone to abnormal neurological signs in tone, coordination and reflexes due to their neonatal complications which lead to developing motor deficits and delays in these children at the age of 6 months or later (11). In general, the shorter the gestational period or the lower the birth weight is, the greater the risk status for motor deficits in the premature infant (1). It is reported that approximately 10% of the ELBW (< 1,000 grams) preterm infants will develop cerebral palsy (CP). Also a 32% rate of CP is found in those infants weighting less than 1,500 grams (1).

Grantham et al in1998 (12) showed that LBW infants had significantly lower scores in mental and psychomotor development index at 6 months of age and the difference in both of these scores increased by 12 months of age. In a study by Datar in 2009 (13), mental and motor development of VLBW and MLBW babies during the first two years of life was compared with those of normal birth weight ones. LBW had a small adverse effect on mental and motor development in the first two years of life.

ELBW infants are rarely admitted in Aliasghar NICU. However, other studies evaluated the ELBW infants or the infants born less than 29 weeks gestation which was not considered in our study. (9,14)

In these studies the development of LBW infants without considering the effects of length of stay or days of MV was investigated and showed relatively poor outcome of growth and psychomotor development in these populations. Moreover, most of these studies were carried out in developed countries. Taking this into account, we reviewed a follow up study in Iran in 2008, in which fifty LBW preterm neonates admitted to Shahid Sadoughi Hospital NICU were evaluated for developmental status at 6 and 12 months of age using Persian version of Ages and Stages Questionnaires (ASQ). LBW and preterm infants admitted to the NICU showed degrees of developmental delay at the ages of 6 and 12 months, especially in the gross motor and personal-social developmental domains on the ASQ (15). Also, in Yazd, Iran, NBW and moderately low birth weight (MLBW) children of 60-month evaluated by ASQ. The results showed that frequency of developmental delay in gross motor, fine motor and problem solving domains were significantly higher in MLBW group and mean score in all developmental domains was statistically significant lower in case group. (16)

As previous studies reported, the MV is often required by preterm infants with respiratory failure, and invasive form of this respiratory support can be related to lung injury and adverse neurologic outcomes (17). In the study of MV in preterm infants in 1992, Graziani et al.(18), described the relationships of prenatal factors, especially those associated with mechanical ventilation and hypocarbia, to the subsequent occurrence of neurosonographic and neurodevelopmental abnormalities in preterm infants. They suggested that prenatal and neonatal factors including the need for mechanical ventilation beginning on the first day of life and marked hypocarbia during the first 3 postnatal days are associated with an increased risk of damage to the periventricular white matter of some preterm infants and developmental delays.

Based on the study of Walsh et al. in 2005, (5) MV in an ELBW neonate has been linked to poor neurodevelopmental (ND) outcomes. Laptook et al. in 2005 (6) demonstrated that developmental risks were greater with increased duration of MV. Van

Marter et al. (19) in 2011, and Thomas et al. (20) determined whether MV's effect on ND is a result of its relationship to BPD and other associated neonatal co morbidities, or whether MV alone is an independent risk factor for poor ND outcomes. They compared the potential impact of MV vs. continuous positive airway pressure (CPAP) at 24 h of age on ND outcomes at 18 to 22 months corrected gestational age (CGA), and analyzed other important neonatal morbidities to ensure that any relationship between mode of ventilation and ND outcome was independent of co-morbid conditions. They found that ventilatory strategy at 24h of age independently predicts long-term neurodevelopmental outcome in ELBW infants.

The use of different inclusion criteria makes it difficult to compare the results of this study with previously reported outcome studies. Most of these studies reported outcome according to birth weight and only included extremely preterm or ELBW infants. Nonetheless, in our study we could not find ELBW infants matching our inclusion criteria. It seems that it may occur in the light of more adverse conditions of these infants in Iranian NICU. As a result, we can discuss only LBW and VLBW infants. The results indicated that although DMQ of both MV and WMV groups is significantly poorer than NBW group, this difference was more in MV group especially in fine motor quotient of VLBW infants in comparison to NBW group. These lower results in fine motor development and especially in VLBW were similar to cohort study by Goyen and Lui in 2002. In this study there were no correlations between motor quotients and gestational age, sex, length of stay in NICU and days of mechanical ventilation in LBW group. However, some researchers found a relation between motor quotients and gestational age. This may be caused by small sample of infants or other possibilities that should be investigated later.

In our study there were some limitations such as low parental cooperation and refusal to attend hospital for tests, fatigue and the children's need to rest frequently and the small sample size that interfere with our study. We just evaluated the motor development and more diagnostic evaluations in form of follow up study and in all aspects of development conduct on LBW infants with and without MV and in more days use of MV are suggested.

Conclusion

The result of this study indicates the importance of special attention to developmental follow up of high risk and LBW infants, especially more complicated LBW infants. It suggests more early detection and early developmental intervention for these infants. We hope for further studies in the field of developmental assessment and early rehabilitation of high-risk infants in our country. Our results can be used by practitioners in their evidence based clinical works especially in developing countries.

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