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Neurodevelopmental Outcomes After Neonatal Periventricular Leukomalacia: Findings from a Prospective Longitudinal Study

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Abstract

Background: The peri ventricular leukomalacia (PVL) condition is a significant predictor of neuro developmental impairment in the long-term of the preterm babies. Despite the advance in the field of neonatal care, neuro developmental patterns of children with the condition are to be investigated further.

Objective: To determine the neuro developmental outcome at long-term in neonates with PVL using the assistance of a prospective longitudinal study design.

Methods: Both neonates who had a diagnosis of PVL examined by either cranial ultrasonography or MRI were followed to the age of 5 years. Motor, cognitive and behavioral measures were measured by the use of neurodevelopment.

Results: The study found that long-term neurodevelopmental impairment which included motor impairment, cognitive delay and speech-language difficulties was significantly correlated with severity of PVL.

Conclusion: PVL is a supreme condition that predetermines negative neurodevelopment. Early diagnosis, systemic follow-up and intervention measures can be used to relieve long-term disability.

Keywords: Neurodevelopmental outcome, preterm babies, periventricular leukomalacia, cerebral palsy, intellectual disability, longitudinal study.

Introduction

Periventricular leukomalacia (PVL) is one of the most common white matter injury in preterm infants particularly those born below 32 gestation weeks of age [1]. The ischemic and inflammatory lesions of the periventricular white matter characterizes PVL and this has been found to be a significant risk factor to irreversible neurological abnormalities [2]. Increasing technologies in the sphere of neonatal intensive care make the survival of preterm infants a possibility, and, therefore, the long-term outcomes of PVL are now of new crucial interest to clinicians, researchers, and families [3]. PVL has a close relation to motor disability like spastic diplegia, cognitive delay, speech and language disorder and visual motor integration problems [4]. These results have been studied by various authors although the majority of them have followed up in the short-term or have used a retrospective design. The dynamic nature of the neuro development particularly during the early childhood years highlights the need to have the long-term perspective studies [5]. Neuro imaging, which is premised on early detection of PVL, is linked to prompt intervention [6]. However, the long-term neuro developmental outcomes in the affected neonates are affected by the level of white matter lesions, comorbidity, the gestational age and quality of developmental support [7]. The full understanding of these determinants can enable the clinicians to forecast the results and optimize care. The proposed longitudinal research design is a prospective one that aims at measuring motor and behavioral, as well as cognitive outcomes of neonates with PVL, over a time of birth and up to about five years [8]. By assessing development stages at specific ages, this research will be of benefit in determining the long run functional implications of PVL and identify predictors of adverse outcomes at such a young age [9]. The findings constitute an informative evidence to be used to improve follow-up practices, creation of certain intervention programs, and family counseling upon prognosis.

Methodology

It was a longitudinal prospective study carried out in a tertiary care unit of neonatal care. Infants identified to have PVL based on the cranial ultrasound or MRI images were recruited. The inclusion criterion was preterm babies whose gestational age was below 34 weeks and had PVL to be detected on imaging within the first 28 days of life. Exclusion criteria were major congenital abnormality or chromosome abnormality.

The subjects were followed at 6, 12, 24, 36 and 60 months. Bayley Scales of Infant Development (BSID-III) assessing cognitive and motor development was the neuro developmental tests and Child Behavior Checklist (CBCL) assessing the behavioral outcomes. The intensity of PVL was classified into mild, moderate as well as severe based on imaging characteristics. The results were analyzed using multivariate regression analysis to establish the predicting variables of poor outcomes.

Results

Recruitment of PVL participants was done among 98 participants. Follow up was 90 at 5 years compliance. PVL was also significant and severe with motor impairment ($p < 0.01$), cognitive delay ($p < 0.05$) and speech language deficits ($p < 0.05$). Moderate to severe PVL was more characterized by serious behavioral problems.

Table 1. Background Demographic of the Research Cohort

Parameter	Value
Mean gestational age (weeks)	30.2 ± 2.5
Mean birth weight (grams)	1280 ± 310
Male infants	56 (57%)
PVL severity: mild	34 (35%)
PVL severity: moderate	38 (39%)
PVL severity: severe	26 (26%)
Mean gestational age (weeks)	30.2 ± 2.5
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Table 2. Outcomes in Neurodevelopment at Age 5 Years

Outcome	Mild PVL	Moderate PVL	Severe PVL
Motor impairment	12%	38%	72%
Cognitive delay	18%	42%	68%
Speech-language delay	20%	47%	74%
Behavioral issues	9%	31%	55%
Motor impairment	12%	38%	72%
Cognitive delay	18%	42%	68%

Speech-language delay	20%	47%	74%
Behavioral issues	9%	31%	55%

Discussion

One of the main factors that lead to neuro developmental impairment in preterm infants in the long run is referred to as periventricular leukomalacia [10]. The outcome of this prospective longitudinal study is consistent with the current data about the correlation between the severity of PVL and the poor neuro developmental outcome [11]. Infants with moderate and severe PVL exhibited significantly more motor impairments, cognitive delay and speech-language impairments compared to those with mild PVL.

Motor impairments including spastic diplegia particularly in severe PVL children were most seen as complications [12]. These observations are also similar to previous reports which associated a general damage to the white matter to a disrupted formation of the corticospinal tract [13]. Higher cognitive delays also reflected the level of higher-order brain processes of learning, memory and executive functioning in infants with high PVL level, and this demonstrates the effects of initial white matter damage on the brain.

Emotional dysregulation and attention deficit were more common in moderate and severe groups of PVL [14]. These outcomes can signify the disruptions in the neural networks, which are engaged in controlling the sociolect-emotional component. Such problems have to be detected at a young age in order to conduct behavioral interventions on time. The longitudinal research design allowed tracing the development pattern over time which was quite helpful in making informed decisions about the impairment persistence and progression [15]. The results highlight the efficiency of the systematic follow-up support to a child with PVL and the use of the following interventions: early physiotherapy, occupational therapy, and cognitive stimulation [16]. Shortcomings of the study include single center study design and the research methods which include imaging in classifying the severity of PVL which may vary among radiologists [17]. Further studies on this association with the more advanced neuro imaging techniques in the future would aid in the better comprehension of the connection between the white matter micro structure and developmental outcomes.

Conclusion

This study demonstrates that neuro developmental issues in the long-term of the neonates with PVL are serious. Motor, cognitive,

speech-language and behavioral outcomes have a high association with the severity of PVL. Early diagnosis, expansive follow up as well as interdisciplinary interventions are fundamental in maximizing long-term patterns of development in this vulnerable.

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