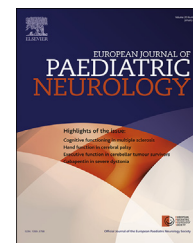




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Original article

Hand function assessment in the first years of life in unilateral cerebral palsy: Correlation with neuroimaging and cortico-spinal reorganization



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ABSTRACT

Aim: The purpose of the present study was to correlate early hand function assessment during the first years of life with neuroimaging findings and the different patterns of cortico-motor reorganization in children with unilateral cerebral palsy (UCP).

Methods: We conducted a long prospective observational study, in which 17 children with UCP (8 left-sided hemiplegia; Manual Ability Classification System level 1–3) were first assessed at a mean age of 24 months (range 18–28), and followed up by means of the Besta Scale, a new standardized protocol assessing both unimanual and bimanual hand function. They also underwent Melbourne Assessment of Unilateral Upper Limb Function (MUUL) and single-pulse Transcranial Magnetic Stimulation (TMS) at a mean age of 10 years 5 months (range 9 y 1 m–12 y 8 m). Brain MRIs of all the 17 children were independently assessed and scored by two blinded observers, according to a defined protocol. Possible correlations between hand function at first assessment, neuroimaging and TMS data were analyzed.

Results: Early hand function impairment significantly correlated with the extension of brain damage ($\rho = -0.531, p = 0.028$), number of involved areas ($\rho = -0.608, p = 0.010$), presence of radiological signs of cortico-spinal degeneration ($\rho = -0.628, p = 0.007$), and basal ganglia involvement ($\rho = -0.485, p = 0.049$). Additionally, higher hand function scores (i.e. better hand function) at first assessment significantly correlated with contralateral cortico-spinal projections, while lower scores significantly correlated with either mixed or ipsilateral cortico-spinal projections to the affected hand ($\chi^2(2) = 11.418, p = 0.003$; post-hoc tests: contralateral TMS group versus ipsilateral: $Z = -2.943, p = 0.002$ and contralateral TMS group versus mixed: $Z = -2.775, p = 0.006$).

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Conclusions: To our knowledge, this is the first study correlating hand function assessment in the first years of life, and its evolution over time, with neuroimaging and cortico-spinal projection patterns in children with UCP. These findings could contribute to an improved prediction of prognosis and a better delineation of therapeutic interventions in young children with UCP.

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1. Introduction

Hand function impairment is acknowledged to be the cause of major disability in children with unilateral cerebral palsy (UCP). Parents and professionals dealing with a child with a recent diagnosis of UCP need information on the severity of impairment, not only to predict long-term functional outcome, but also for a more focused approach to rehabilitation. Over the past two decades the increasing use of conventional Magnetic Resonance Imaging (MRI) has provided some useful information on the association between brain structural abnormalities and motor impairment in children with brain lesions.^{1–4} More recently, the development of validated and reliable disease-specific assessments has provided more detailed information about hand function impairment in children with UCP, and the possible evolution over time.^{5–7} However, hand function has been less investigated in very young children, as studies were mainly focused on children over the age of 4 years, and data on the correlation between hand function assessment and brain damage in very young children with UCP still remain limited.

Also, the use of neurophysiological techniques has greatly improved our understanding of the mechanisms underlying functional reorganization in patients with early cerebral lesions. More specifically, the use of Transcranial Magnetic Stimulation (TMS) has shown that in children with UCP, cortico-motor projections can be contralateral, ipsilateral or mixed, depending on whether the affected hand receives projections from the contralateral, ipsilateral or both the hemispheres.^{8,11} It has been reported that patients with ipsilateral cortico-spinal projections show more severely impaired hand function than patients with contralateral projections, although this does not always hold true in individual cases.^{8–11} Additionally, increasing debate about the influence that the different patterns of cortico-spinal reorganization may have on the efficacy of functional therapeutic approaches such as constraint induced movement therapy (CIMT), has emerged among researchers.^{12,13}

The aim of the present study was to correlate early hand function assessment during the first years of life with neuroimaging data and the different patterns of cortico-motor reorganization on TMS in a cohort of children with UCP.

Our hypothesis was that early hand function assessment was strongly related to the degree of brain damage, and that these data could be associated with the different cortico-projection patterns assessed on TMS at a later age.

2. Materials and methods

2.1. Participants

Participants were recruited among children with a diagnosis of cerebral palsy referred to the Developmental Neurology Unit, Carlo Besta Neurological Institute, Milan, Italy. The diagnosis of UCP was formulated on the basis of clinical history, neuroimaging and clinical features by a team of expert and trained paediatric neurologists and therapists (GB, EP, MTA, AC, MF, AM). Children were enrolled according to the following criteria: age 18–36 months; magnetic resonance imaging (MRI) confirming the presence of unilateral brain abnormalities or lesions of antenatal-perinatal origin such as maldevelopments, periventricular white matter lesions, grey matter lesions; absence of epilepsy at the enrolment or during the follow up period; availability to attend regular treatment and follow-up at our Institution. Children with hemiplegia clearly acquired after the neonatal period (e.g. as a consequence of traumatic brain injuries or tumours) were excluded. The diagnosis of UCP was formulated on the basis of the criteria proposed by the Surveillance of Cerebral Palsy in Europe,¹⁴ i.e. involvement of limbs on one side of the body, and at least two between i) abnormal pattern of posture and/or movement, ii) increased tone (not necessarily constant), and iii) pathological reflexes (increased reflexes: hyperreflexia and/or pyramidal signs, e.g. Babinski response).

The children were enrolled between March 2002 and December 2004, and followed up until December 2012 as part of a long prospective observational study.

The study was approved by the Research Ethics Board at the Carlo Besta Neurological Institute in Milan, Italy. Informed written consent was obtained from the parents.

2.2. Hand function assessment

The Besta Scale, developed since 1985 at our Institution, was used to assess quality of grasp (hand function on request) and spontaneous hand use (bimanual integration), as different validated hand function assessments were not available for young children with UCP at the time of study enrolment.

The Besta Scale has been recently validated in a wide sample of children with UCP from the age of 18 months to 12 years, showing good reliability and validity.¹⁵ The different items of the Besta Scale have shown high internal-consistency

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