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Original article

Neuro-motor evaluation of patients with spastic cerebral palsy treated with orthopedic surgery in the Instituto Nacional de Rehabilitación

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ABSTRACT. ***Background:*** **Cerebral palsy (CP) is a static neurologic condition resulting from a brain lesion occurring before the completion of brain development. The goal of management is not cure, but increasing patients' functionality and improving their capabilities and maintaining their locomotion, cognitive development, social interaction and independence. The best results are obtained with an early and intensive management that includes physical and occupational therapy, medical and surgical treatments, mechanical aids and the management of concomitant conditions.** ***Objective:*** **To assess the neuromotor improvement in patients with spastic CP after surgical treatment at the National Rehabilitation Institute.** ***Patients and methods:*** **Patients with a diagnosis of spastic CP who presented at the Pediatric Rehabilitation outpatient service were referred to the Joint CP Clinic from January 2007 to January 2008, and underwent surgical treatment of the pelvic limbs. They were assessed 3 times and underwent neuromotor tests with gross motor function measure (GMFM), which was rated with the gross motor function classification system (GMFCS).** ***Results:***

RESUMEN. ***Antecedentes:*** **La parálisis cerebral (PC) es una condición neurológica estática resultante de una lesión cerebral antes que el desarrollo cerebral sea completo. La meta en el manejo no es curarlos, sino aumentar su funcionalidad, mejorar sus capacidades y mantener la locomoción, el desarrollo cognitivo, la interacción social y la independencia. Los mejores resultados se obtienen de un manejo temprano e intensivo que involucra terapia física y ocupacional, tratamientos médicos y quirúrgicos, ayudas mecánicas y el manejo de las condiciones asociadas.** ***Objetivo:*** **Evaluar la mejoría neuromotora en pacientes con PC espástica posterior a tratamiento quirúrgico en el Instituto Nacional de Rehabilitación.** ***Pacientes y métodos:*** **Pacientes con diagnóstico de PC espástica que acudan a la consulta externa de Rehabilitación Pediátrica, presentados en la Clínica Conjunta de PC de Enero de 2007 a Enero de 2008, que se realizó tratamiento quirúrgico de miembros pélvicos. Fueron evaluados en tres ocasiones con unas pruebas neuromotoras con medición de la función motora gruesa (GMFM) y calificada con el sistema de clasificación de la función motora gruesa (SCFMG).**

Level of evidence: IV (Act Ortop Mex, 2010)

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Most of the patients had improvement in the muscle tone and contracture assessments as well as in the GMFM, and their self-mobility increased one level. *Conclusions:* Significant improvements were seen in the muscle tone and contractures after surgery; the GMFM and the self-mobility levels in the GMFCS also improved. Multiple level surgery together with a postoperative physical therapy program results in considerable improvements in the gross motor function measure of patients with spastic CP.

Key words: evaluation, surgery, cerebral palsy, rehabilitation, muscle spasticity.

***Resultados:* La mayoría de los pacientes mejoraron en la evaluación del tono y contracturas musculares y en el porcentaje de GMFM además de que modificaron su nivel de auto-movilidad hacia un nivel inmediato superior. *Conclusiones:* El tono y contracturas musculares presentaron mejorías significativas posterior a la cirugía así como el porcentaje de GMFM y los niveles de auto-movilidad del SCFMG. La cirugía de multinivel asociada a un programa de terapia física postquirúrgico produce mejoría considerable en la función motora gruesa de los pacientes con PC espástica.**

Palabras clave: evaluación, cirugía, parálisis cerebral, rehabilitación, espasticidad muscular.

Introduction

Cerebral palsy (CP) represents one of the most common diseases in Pediatric Rehabilitation, this disorder occurs in about 2-2.5 out of every 1,000 live births worldwide.[1]

It is a term that encompasses a group of syndromes with motor deficit that are non progressive, secondary to injuries or abnormalities in a brain that is in the first stages of development.[1]

It is characterized by a motor handicap and it may be accompanied by physical and mental dysfunction. In the United States it is estimated there are 764,000 patients (children and adults) with cerebral palsy. Moreover, an estimated 8,000 newborns and infants and 1,500 toddlers are diagnosed with cerebral palsy every year.[1-4]

There are several tools to quantify motor development, development milestones and motor skills to determine the quality of life of patients with CP and their primary care givers.[5-7]

Aside from the development disorders that individuals with CP may present as a result of a handicap of the central nervous system in development, the framework of this disorder includes development disturbances in the gross motor function.[5,8]

When parents are informed that their child suffers from CP, which generally happens in the first years of life, what they are more interested in knowing is the severity of it and if their child will be able to walk or not. Until recently, the evidence we had to answer these questions was limited to observation of the association between primitive reflexes and early motor skills at two years and gait at a later age, on the other hand, milestones of motor development such as seating between two and four years of age and gait at a later age.[8-10]

However, findings based on these simple markers are conflictive since some authors estimate that the probability of taking ten steps without help at five years or after five years varies depending on the clinical variety of CP.[5]

Some cross sectional studies about the motor behavior of children with CP have shown characteristic patterns of motor development according to the severity of the disease.[11-13]

Motor development curves created by Palisano et al, which are based on cross sectional studies of stratified populations and validated by the Gross Motor Function Classification System (GMFCS) for CP are very useful to classify motor development of patients.[14-16]

Measurement of Gross Motor Function (GMFM) designed and validated by Diane Russell of Chedocke MacMaster Hospital in Ontario, Canada, is an observational reference criterion that has been developed and validated to evaluate children with CP. The original GMFM was modified in 1990; authors based it on the feedback of physicians and examiners who use it. Three items were added to the original measurement of eighty five items in an effort to allow for bilateral evaluation of these items.[17,18]

Although as progress is made in the application, each item increases in difficulty, its order was based on clinical judgment and the literature, and the order was taken into account for easy application.[19]

For five years of age, children without motor development delays are capable of completing all items of the GMFM. The score for each category is expressed as a percentage of the maximum score for each one of them. The total score is obtained with an average of percentage scores of the five categories.[19]

Originally, what we wanted to obtain with the GMFM, was a measure that could be used by children through a spectrum of activities so that children with different gross motor skills could be included in clinical trials and be evaluated by the same tool; as well as to become a useful tool to make periodic evaluations of children and thus have a follow up.[20]

The ability to detect changes in patients through the GMFM has been supported by several analyses of children's scores that were evaluated one or more times by this tool, by the same person, in an interval of five to seven months. For

children with cerebral palsy, changes in the total GMFM score has been related to the perception of change by the parents, by the children's therapists and by changes validated by examiners.[18]

Several studies have shown that improvement in GMFM scores is better in children who are recovering from an acute brain injury, followed by toddlers without motor development delays and lastly by children with CP.[21-24]

Researchers have used the GMFM in children with spastic CP to validate the effectiveness of rhizotomies, intrathecal baclofen, physical therapy, horse-assisted therapy, electro-stimulation, orthosis and tendon elongations.[19,20,25,26]

The Gross Motor Function Classification System (GMFCS) was developed by Palisano et al. in order to have a tool to document gross motor function in children with CP, since there was no standardized system to classify skills and limitations of gross motor function.[4,10,27,28]

The GMFCS is based on the concepts of skill and limitations of gross motor function and it is similar to the staging systems used to describe cancer.

The GMFCS is designed for children with CP under twelve years old. The system has five levels based on differences in movement initiated by the patient with particular emphasis in seating and walking. The five levels represent differences in the gross motor function which are important for the patient's daily activities.[4,11,17,29,30]

The objectives of this study were:

- To evaluate neuro-motor improvement in patients with spastic cerebral palsy after surgical treatment in the Instituto Nacional de Rehabilitación.
- To identify changes in muscle tone, joint mobility and contractions in patients included in the study.
- To evaluate improvement in gross motor function in patients with CP after surgical treatment, through the application of the GMFM.
- To prove possible changes in the self-mobility levels in patients included in the study by applying the GMFCS.

Material and methods

This is a descriptive, longitudinal, prospective, deliberate intervention and open trial.

Patients included in this trial are those with a diagnosis of spastic CP that come to the outpatient clinic of Pediatric Rehabilitation presented in the Cerebral Palsy Joint Clinic of the *Instituto Nacional de Rehabilitación* and who are chosen for surgical treatment of lower limbs.

Inclusion criteria

- Diagnosis of spastic CP.
- Children over 2 years and less than 12.
- Parent's consent of participation.
- Boys or girls.
- Patients presented in the CP Joint Clinic.

Exclusion criteria

- Dyskinetic, ataxic or combined clinical forms.
- Patients with congenital heart disease or active epilepsy.
- Patients who had orthopedic surgery prior to the trial.
- Patients undergoing surgical treatment of upper limbs.
- Need for surgery due to scoliosis.

Elimination criteria

- Patients with post-operatory complications.
- Withdrawal from the post-surgical rehabilitation program.
- Patients who did not take the tests in any of the evaluation moments.

Patients were evaluated on three occasions

- 1st evaluation (Pre-surgical): After deciding which surgical procedure will be performed.
- 2nd evaluation: Three months after surgery and after immobilization is removed.
- 3rd evaluation: Six months after surgery.

The first pre-surgical evaluation included the following Neuromuscular Evaluation,

- Application of the GMFM.
- Application of the GMFCS.

Once surgical treatment was performed in the *Instituto Nacional de Rehabilitación* and three months after surgery, when the cast is removed, a second evaluation was performed and another one after six months, applying the scales mentioned.

Then we will have three scores, a pre-surgical and two post-surgical scores in order to evaluate the patient's gross motor function in a more objective manner.

The following analysis was performed:

1. Reliability: of the scales with Cronbach's α.
2. Friedman Test to compare κ of related samples in the pre-surgical, first and second postsurgical evaluation.
3. Multivariate to evaluate the effects of age and sex on other changes in the Gross Motor Function scales.
4. Correlation tests between the Gross Motor Function scales adjusted for age and sex.
5. Data of the evaluation were gathered and downloaded into Microsoft Office Excel 2007 and we used the SPSS Program version 15.0 for Windows XP.

Informed consent

The parent or tutor of all patients was given an informed consent to be read and decide to participate in the trial, and then the first corresponding evaluation was performed.

Results

A total of 30 patients was evaluated, 15 (50%) were male, and the rest were females. In terms of age, 18 patients (60%) are between 2 and 6 years and the rest between 7 and 12.

With regards to the patient's topographic forms of Cerebral Palsy in the sample, a summary is presented in *chart 1*.

Table 1 expresses the mean values and standard deviation in the different evaluations where there was considerable increase in percentages obtained in the GMFM as of the initial evaluation up to the final evaluation at 6 months in the three CP topographic forms with highly significant values for spastic quadriparesis and diparesis. In spastic hemiparesis results reflect statistical significance, however the fact that we started with very high values (92.1%) in the preoperative evaluation, makes the values of the final evaluation less remarkable.

Results obtained in *table 1* are illustrated in *chart 2* showing percentages of change from the basal to the final evaluation in the different topographic forms of CP and we observe that in quadriparesis from baseline to the second evaluation, there is 15.4% of change and from the second to the third evaluation 26.1%. Likewise in spastic diparesis we can also observe high change percentages (4.90 and 9.20%) which does not happen in hemiparesis where change percentages are very low (0.10 and 2.10%) since, as was mentioned before, in this topographic form the initial GFMF percentage is very high because most children are ambulatory patients at early ages making the gross motor percentages substantially increase.

In the final evaluation (6 months) of patients with spastic diparesis, we can once again corroborate the significant correlation between the GMFM and the GMFCS, by obtaining a higher percentage of the first one; we obtain a better level in the second one *(Chart 3)*.

At the end of the evaluations, patients in the spastic hemiparesis group show a significant correlation between the GMFM and the GMFCS, the higher the final percentage obtained, the higher the level reached by patients in the Classification System *(Chart 4)*.

Table 2 shows the initial and final classification according to the GMFCSE in the total sample studied:

- Level V: out of 15 patients who started in this level for the final evaluation, 11 ended up in the same level and 4 went on to level IV.
- Level IV: out of 3 patients in this level at the beginning of the evaluation, one remained in this level and 2 went on to level III.
- Level III: out of 7 patients, 1 remained in the same level, 5 went to level II and one ended up in level I.
- Level II: out of 3 patients at the beginning in this level, 1 remained in this level and 2 ended up in level I.
- Level I: 2 patients started and remained in it after 6 months.

In general we showed that 14 patients (46.6%) changed their level of self-mobility to the next upper level which reflects they obtained superior qualitative modifications.

With regards to muscle tone, there was significant improvement in patients with spastic quadriparesis and spastic diparesis, even though most of them showed a 1 in the Ashworth scale modified both for hips as well as for knees and ankles.

Muscle contractions improved significantly in the three topographic forms both for hip flexors, hamstrings and bilateral rectus femoralis.

Discussion

The goal in managing patients with cerebral palsy is not to cure them but to increase their functionality, improve their capacities and maintain locomotion, cognitive development, social interaction and independence. The best results are obtained with early and intensive management.[12]

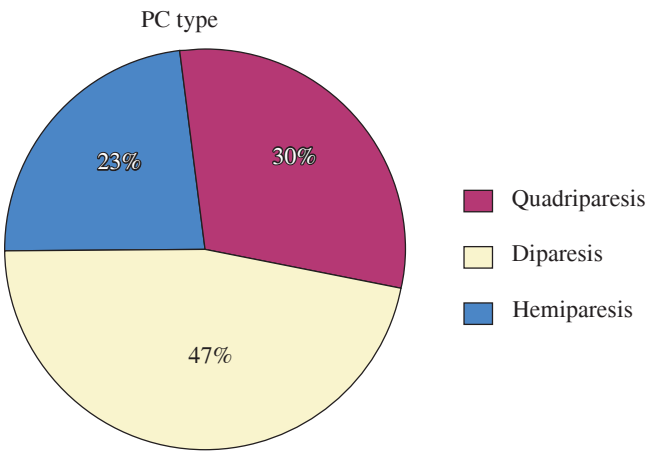

Chart 1. Distribution of the sample according to the topographic form of cerebral palsy (CP).

Table 1. Mean values and standard deviation of the gross motor function measurement (GMFM) at different moments of evaluation according to the topographic form of cerebral palsy.

	CP Subtype		
Measurement	Quadriparesis (n = 9)	Diparesis (n = 14)	Hemiparesis (n = 7)
Basal preoperative	13.6% (5.4)	58.6% (23.6)	92.1% (5.0)
Postoperative 3 months	15.7% (6.1)	61.5% (23.1)	91.0% (8.7)
Postoperative 6 months	19.8% (6.7)	67.2% (23.4)	93.0% (7.9)
P	0.0001	0.0001	0.019

In spite of modern improvements in prenatal care, the incidence of cerebral palsy has increased due to the greater survival of children with low birth weight. The use of non orthopedic interventions such as: botulinum toxin and baclofen intrathecal pumps has increased, however, most of the ambulatory and non ambulatory pediatric patients with cerebral palsy will present muscle-skeletal deformities and they will be candidates for surgical treatment.[23,24]

The patient's age at the moment of surgery is important since toddlers are more prone to contractions due to continuous growth. The typical gait pattern becomes an adult pattern at around seven years of age; therefore surgical intervention in very small children rarely leads to long lasting improvements during growth.[24]

Surgery at multiple levels consists of a combination of neurectomy, tenotomy, arthrodesis, osteotomy, tendon elongation, vertebral fixation, etc., which has proven to be the criteria to follow in patients with cerebral palsy who are candidates for orthopedic surgery.[27]

Koman concluded that tenotomy of adductors and iliopsoas with 50% subluxation prevents dislocation and improves coverage in 80% of children with CP. Presedo et al. in a sample of 65 children with CP after undergoing tenotomy surgery of adductors and iliac psoas proved that 74% improved the gross motor function and infrared radiation IR was the best predictor of good results. Femoral correction before 5 years of age guarantees hip stability; while Pirpiris et al. determined that elongation of hamstrings decreases contraction during flexion. Likewise, Spiro et al. proved that multilevel surgery improves patient's postoperative motor function.[28]

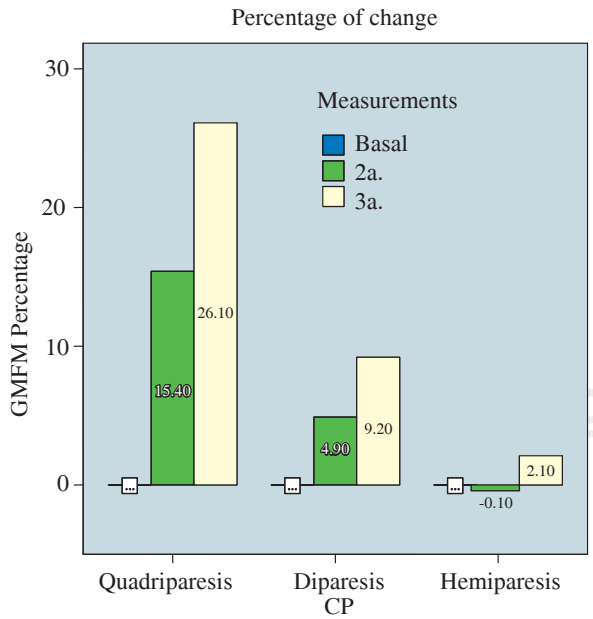

Chart 2. Percentages of change in the Gross Motor Function Measurement (GMFM) at different moments of evaluation according to the cerebral palsy subtype.

In our sample of patients we observed that through all evaluation methods (Neuro-motor Evaluation, GMFM and GMFCS) there are significant changes starting with the preoperative evaluation up to the third evaluation at six months. Those who presented quadriparesis and diparesis showed more significant changes; this is logical and expected since hemiparetic patients tend to reach higher percentages in the GMFM since the first evaluation, and they are also at the highest levels in the CMFCS. It is also harder for them to show significant changes as the other two groups of patients since the skills they can't complete are the only ones expected to be normal in patients without any type of motor handicaps.

It is also worth noting that patients with spastic quadriparesis show very little or no improvement in the basal and final GMFCS since we know that the purpose of multilevel surgery in these patients is to facilitate the caregiver's hygiene activities more than improving mobility and functional capacity of patients.

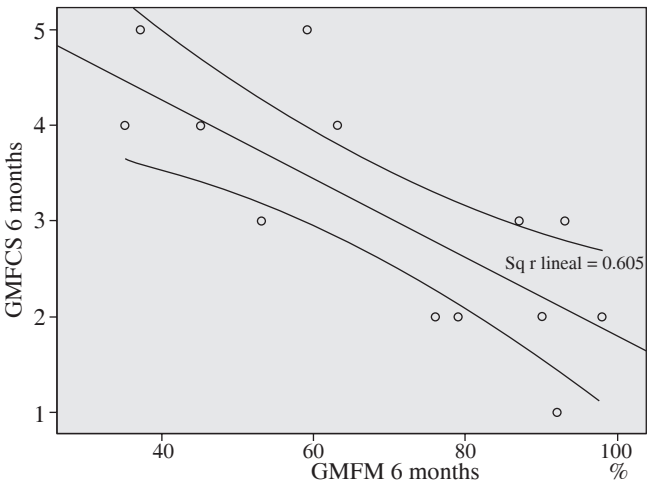

Chart 3. Correlation between GMFM at 6 months and GMFCS at 6 months in patients with diparesis.

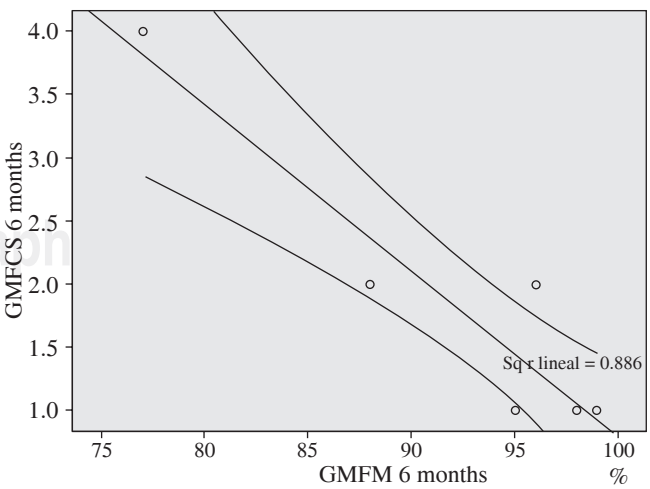

Chart 4. Correlation between the GMFM at 6 months and GMFCS at 6 months in patients with hemiparesis.

Table 2. Changes in the initial and final GMFCS in the total sample of patients with cerebral palsy.

	Final GMFCS						
Initial GMFCS	Level V	Level IV	Level III	Level II	Level I	No.	%
Level V	11	4	–	–	–	15	50.0
Level IV	–	1	2	–	–	3	10 .0
Level III	–	–	1	5	1	7	23.3
Level II	–	–	–	1	2	3	10.0
Level I	–	–	–	–	2	2	6.7
No.	11	5	3	6	5	30	100.0
%	36.6	16.6	10	20	16.6	100	

It is interesting that in patients with spastic diparesis and hemiparesis the percentages obtained in the initial GMFM, at 3 and 6 months correlate directly with levels reached in the GMFCS; therefore the greater the gross motor function percentage, the greater the level of self-mobility obtained.

In patients with quadriparesis there are neuro-motor variables that were statistically significant at the basal and final evaluations; such as tone of both hips, knees and ankles, contractions of hip flexors and hamstrings; proving that multilevel surgery of lower limbs has an appropriate result in this group. On the other hand, prediction of contractions in hip flexors becomes interesting in relation to the percentage obtained in the final GMFM, since the higher the percentage of gross motor function the lower the degree of contractions.

In patients with diparesis the hip, knee and ankle tone, as well as the contraction of hip and hamstring flexors and rectus femoralis improve after surgery, thus proving its usefulness. As happens in quadriparetic patients, hamstring contractions show a significant prediction compared to the GMFM.

Lastly, patients with hemiparesis show statistical significance for ankle tone, contraction of hamstrings and rectus femoralis on the affected side in the basal and final evaluations. Once again the GMFM shows a prediction in the tone of the lower member affected at the end of the evaluation.

In conclusion changes in the tone and muscle contractions showed statistically significant changes after surgical treatment. Measurement of Gross Motor Function was a very useful tool to show the improvement obtained by patients with Cerebral Palsy treated with multilevel orthopedic surgery with highly significant results.

Modifications in self-mobility levels of the Gross Motor Function Classification System were evident in the final evaluation; however these results did not obtain statistical significance given the complexity required to achieve changes in the self-mobility level, therefore patients may even improve their motor function level within the same level of self-mobility.

Multilevel surgery associated to a physical therapy program post-surgery produces considerable improvements in the gross motor function of patients with spastic Cerebral Palsy.

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