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BRAINCHILD

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Special Issue on Cerebral Palsy in Hong Kong

香港兒童腦科及體智發展學會
The Hong Kong Society of Child Neurology and Developmental Paediatrics

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SPECIAL ISSUE ON CEREBRAL PALSY IN HONG KONG

CONTENTS

The Hong Kong Society of Child Neurology and Developmental Paediatrics

EDITOR'S NOTES for the December 2014 Issue

Cerebral Palsy (CP) in Hong Kong: Dynamic Evolution in the recent Eight Decades

Dr. Chok Wan CHAN

The current issue of Brainchild is devoted to Cerebral Palsy. It is capably created by our Guest Editors: Professor Joe Watt and Dr. Wong Lai Yin. Professor Watt is a world renowned physiatrist currently stationed in Canada. He is an experienced paediatrician originally from Hong Kong and is the second Course Director of the Hong Kong Society of Child Neurology and Developmental Paediatrics in 1995 and has been our Honorary Advisor ever since in advising our Society in the development of physiatry in Hong Kong. He is a frequent participant at our Annual Scientific Meetings and most of our major professional activities. Through his advice and instructions, our Society grows and flourishes into the current state of maturity. To all his contributions, we would like to express our heartfelt gratitude and look forward to his continual support and patronage to our Society. Our Issue Co-Editor Dr. Wong Lai Yin is an experienced developmental paediatrician specialized in the care and in rehabilitation of children with physical impairments. We are very pleased that the two of them have collaborated more than a dozen of local child healthcare professionals consisting of doctors, nurses, social workers, clinical psychologists and allied health professionals to produce this Issue covering the most-up-to date definition, early diagnosis, assessment, management, rehabilitation and best means in returning to the community for children with cerebral palsy exemplifying modern holistic approach to child health problems in transdisciplinary team collaboration involving individual, family, school and the community and covering the major sectors of medical, social and education. The issue is indeed an encyclopaedia for modern management of cerebral palsy in Hong Kong.

Management of children with cerebral palsy and other conditions with physical impairments underwent several distinct stages in Hong Kong. The cradle for such development started in 1962 when Queen Mary Hospital was built in Pokfulm, Hong Kong. In the era before 1962, all these children were under the care of adult physicians because paediatricians were virtually non-existent in this Pearl of the Orient. In those days most of the cerebral palsy were due to congenital anomalies, asphyxia neonatorum, birth trauma, kernticutus, infections, accident and injuries. Neither specific nor supportive treatments were available for CP and most of the children disappeared soon after their first visit in Hong Kong being kept always from the urban areas due to social stigmata and feeling of shame and guilt created on parents due to social prejudice. This is the ***pre-historic phase*** for management of CP in Hong Kong.

The next milestone was the year 1962 when the Department of Paediatrics was established at the University of Hong Kong. During the period between 1962 and 1969, child

neurology cases including CP started to be seen by a few interested general paediatricians of the time. The most significant achievement of the period was a longitudinal study conducted by Professor C. Elaine Field and Dr. Flora Baber on child development for children in Hong Kong as well as the establishment of the Spastic Association of Hong Kong. This period can be seen as ***the incubation period*** for the child neurology (CN) and developmental paediatrics (DP).

The ***germination phase*** followed when Dr. Lui Wai Ying pioneered a paediatric service at the University of Hong Kong upon her return from overseas, having acquired state-of-the-art knowledge and experience in child neurology from world renowned centres in the United Kingdom. This marked a new era of child health care and represented an important milestone for the subspecialty. With the further return of more experienced child neurologists from overseas after training, the same team restructured and modernized the management of children with neurological problems through the setting up of Neurology Clinics, use of new investigative tools such as electroencephalograms, electromyograms, nerve conduction studies, muscle biopsies and angiographies, as well as development of rehabilitation and outreach services to the community. New research projects were launched including study of intra-uterine infections, epidemiology and management of cerebral palsy, the Comprehensive Observation Scheme (consisting of the Hong Kong Developmental Screening System by the University of Hong Kong and Comprehensive Child Assessment Services for early diagnoses and assessment of children with CP and other developmental delays by the Department of Health of the HK Government as well as Rehabilitation Services for children with problems so detected. Undergraduate and postgraduate curricula of child neurology including CP were also established and implemented at the University of Hong Kong.

The next phase started in the late 1970‘s when most of the regional hospitals began forming their own services in the care of children with CP following the success of Queen Mary Hospital (from the pioneers in the early days to the current neurologists Professor Virginia Wong, Dr. Ada Yung, Dr. Fung Cheuk Wing and Dr. Sophelia Chan). These include Queen Elizabeth Hospital (Dr. Lily Chiu and Dr. Wu Shun Ping) followed by the Princess Margaret Hospital (Dr. Chan Kwok Yin and Dr. Eric Yau), Prince of Wales Hospital (Dr. Eva Fung), Kwong Wah Hospital (Dr. Sharon Cheuk) Tuen Mun Hospital (Dr. Kwong Ling and Dr. Mario Chak), Caritas Medial Centre (Dr. Kong Chi Keung, Dr. Ko Chun Hung and Dr. Wong Lai Yin), Alice Ho Miu Ling Nether sole Hospital (Dr. Tsui Kwing Wan) United Christian Hospital (Dr. Louis Ma) and Child Assessment Services of Department of Health (Dr. Catherine Lam, Dr. Wong Lai Yin, Dr. Florence Lee and the expert multidisciplinary team of allied health professionals) as well as child neurologist from the private sector (Dr. Sam Yeung, Dr. Chan Yee Shing, Dr. Winnie Yam, Dr. Theresa Wong, Dr. Lau Wai Hung) and others. The standard of practice was high and academic atmosphere was rich. However, inter-service coordination and communication were still very limited. This could thus be viewed as the ***autonomous developmental phase***.

The ensuing ***mature phase*** is marked by the establishment of the Hong Kong Society of Child Neurology and Developmental Paediatrics in April 1994. The Society began as an

interest group comprising members from institutions and private sectors, and later developed into a formal subspecialty society with the objectives of promoting communication among colleagues and coordinating activities between the two subspecialties of Child Neurology and Developmental Paediatrics.

The final stage of development is ***the statutory phase*** when The Hong Kong College of Paediatricians being the statutory body empowered by statue to ensure quality and standard of service, training, education as well as continuing medical education (CME) and continuous professional development (CPD) for paediatrics and paeditric subspecialties was set up in 1991. To achieve these aims, two subspecialty boards, the Child Neurology (PN) Board and the Developmental Behavioural Paediatrics (DBP) Board, were established. Under the capable chairmanship of Dr. Tim Liu and Dr. Catherine Lam for the PN and DBP Boards respectively, one can envisage that the management of CP would improve significantly from now on to enable management of CP in Hong Kong functioning at the best world standard so that all developmental paediatricians and child neurologists would take pride in the care of children with physical impairments.

On looking back, the past eighty years have witnessed immense progress in the management of CP in Hong Kong: from simple assessment by a doctor alone to transdisciplinary team approach, from basic clinical examination to the complex gait lab and computer assisted evaluation, from the primitive high risk investigations such as pneumoencephalograms to the high-tech Magnetic Resonance Imaging (MRI), Positron Emission Tomography (PET) and Single Photon Emission Computerized Tomography (SPECT), from the few classic empirical anticonvulsants to the highly selective and effective treatment regimens today, from the long lists of inoperable cases to current wide spectrum of corrective operations, from those days when child neurologists and developmental paediatricians were rarities to the present day where the expertise is available in most of the regional hospitals in Hong Kong. The advance and progress are highly significant. Above all, the immense contributions from overseas experts such as Professor Joe Watt (consultant physiatrist) and Professor Peter Wong (consultant electrophysiologist) are crucial in these outstanding achievements. For all their contributions, we are grateful!

Finally we would like to convey our deepest appreciation for the good work of all responsible professionals and key players for the care of children with CP in Hong Kong in achieving the top level management *(professionalism)* and for striving for the welfare and rights for our children *(advocacy)* with CP. *I wish you all reading pleasure and best of health!*

Dr. CHAN Chok Wan

Editor-in-Chief, *The Brainchild*
President, The HK Society of Child Neurology & Developmental Paediatrics
28th December 2014.

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What is Cerebral Palsy?

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Cerebral Palsy (CP) describes a group of permanent disorders of the development of movement and posture, causing activity limitation, that are attributed to nonprogressive disturbances that occurred in the developing fetal or infant brain. The motor disorders of cerebral palsy are often accompanied by disturbances of sensation, perception, cognition, communication, and behaviour, by epilepsy, and by secondary musculoskeletal problems.[1] The prevalence of cerebral palsy has remained unchanged at 2.11 per 1,000 live births for 60 years. The prevalence of CP in term infants was unchanged. Those who were born pre-term was also unchanged, because the increased incidence in the extremely premature survivors was balanced by the lower incidence of CP in the more mature premature survivors, due to improved obstetrical care and neonatal intensive care.[2, 3, 4]

55-70% of all children with CP are born at term and of those, only 15-20% could be attributed to term birth asphyxia in developed countries. The majority of the children with CP born at term are due to brain malformation or perinatal strokes, the etiologies of which are basically unknown. Etiological risk factors in term infants include placental dysfunction or abnormalities, birth defects, low birthweight, meconium aspiration, caesarean section, vacuum, breech, neonatal seizures, respiratory distress syndrome, hypoglycemia, infections, especially meningitis and sepsis.[5] There has been better research of perinatal stroke presenting as unilateral cerebral palsy in the first year of life, which accounts for about 38% of all children with CP.[6] Perinatal Stroke Syndromes can be classified according to brain imaging into Presumed Perinatal Ischemic Stroke due to Periventricular Venous Infarction (PVI) at 28-34 weeks of gestation, and Arterial Presumed Perinatal Ischemic Stroke (APPIS) of middle cerebral artery, closer to term. Acute symptomatic strokes due to Neonatal Arterial Ischemic Stroke (NAIS), Neonatal Sinovenous Thrombosis (CSVT) and Neonatal Hemorrhagic Stroke (NHS) occur in the neonatal period.[7] Causative factors are mostly unknown except for maternal hypertension and intrapartum fever.[8]

30-40% of all children with CP are born prematurely. Risk factors include extreme prematurity, periventricular leukomalacia, intraventricular hemorrhage and intraparenchymal haemorrhage grade III-IV, intrauterine infection, transient hypothyroxinaemia, bronchopulmonary dysplasia and necrotizing enterocolitis, surgical repair of patent ductus arteriosus, requirement of home oxygen, abnormal brain ultrasound in deep grey matter and MRI findings of infarction[6].

Early diagnosis of CP is by serial neurological and developmental examination of muscle tone, primitive reflexes, quality and quantity of voluntary movements and involuntary movements, milestone acquisition and upper motor neuron signs. Standardized neurodevelopmental assessment tools including Qualitative Assessment of General Movements, Hammersmith Infant Neurological Assessment, Movement Assessment of Infants (MAI), Test of Infant Motor Performance(TIMP) and Alberta Infant Motor Scale (AIMS) are useful. All children with presumed or suspected CP should have Magnetic Resonance Imaging. Only 12-14% with CP will have "normal" MRI.[6] In those children, diligent search for differential diagnosis must be carried out. Neurodegenerative conditions, metabolic syndromes, autistic spectrum disorders, idiopathic toe walking syndromes and genetic syndromes can mimic CP. Abnormal MRI can often help to estimate the timing of the brain malformation or injury in utero.[9]

For the purpose of habilitation/rehabilitation, once the body structure aspect of a child with CP, according to the International Classification of Functioning, Disability and Health[10], has been defined by detailed assessments, compassionate anticipatory guidance and continuing counseling of the family should be provided by a multidisciplinary team of experts, based on assessment of body function and activity. The classification of motoric function involves the observation of abnormal motor types The most common motoric type is spastic (85-91%), dyskinetic (4-7%), Ataxic (4-6%) and hypotonic (2%)[6]. Topographical assessments include head and neck, trunk, four limbs (Hemiplegia 38%, Diplegia 36%, Quadriplegia 26%)[6] and often oropharyngeal fuction. Classification of gross motoric abilities into 5 levels based on Gross Motor Function Classification Scale (GMFCS), is now used universally[11]. It has prognostic value for ability to walk (Community walkers: Level I 32%, Level II 27%, Assisted and limited walkers: Level III 12%, Non-walkers: Level IV 14%, Level V 15%). Classification of fine motor abilities using Manual Ability Classification System (MACS)[12], Communication Function with Communication Function Classification System (CFCS)[13] Trunk Control Measurement Scale[14], and eating and drinking ability scales[15] are less universally used.

More importantly, every child with cerebral palsy should be assessed for non-motor impairment that will affect activity and response to therapy. This includes cognitive, attention and learning disabilites, epilepsy, speech and language disorders, neuropsychiatric disorders, hearing loss, sensory loss, visual impairment, genitourinary dysfunction, gastrointestinal dysfunction, malnutrition or obesity, feeding and swallowing disorder, oral hygiene and dental health, bone health, pulmonary and sleep disorders.

The intervention and treatment of each child with cerebral palsy is individualized and custom designed, family centered, evidence advised and delivered to the child and family by multidisciplinary specialists, with specific goal setting, within the context of the child participating and integration in his/ her environment and community.[16, 17]

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Serving Children with Cerebral Palsy: Local Scene Perspective from Child Assessment Service

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Introduction

Children with cerebral palsy often have ongoing medical, educational, social and therapy needs. In addition to physical challenges, they may also suffer from epilepsy, behavioural problems, learning difficulties, language and communication problems, visual and hearing impairments.[1, 2] They often require a wide range of services and would benefit from continued and coordinated multidisciplinary health care services.

In Hong Kong, services for these children are available from the public sectors, non-government organizations (NGOs) and the private sectors. The Hospital Authority (HA) provides the majority of medical services while the NGOs provide education and rehabilitation in the community, not only in early childhood, some had extended their services to adolescent and adulthood providing vocational training, daycare and residential care for patients in need.

Local Scene

Over the past decades, there were many changes in the management of children with cerebral palsy in Hong Kong, particularly in the management of spasticity. The use of Botulinum toxin with ultrasound guidance, is now considered a standard practice especially in early childhood.[3, 4] Selective Dorsal Rhizotomy (SDR) was first introduced to Hong Kong in the early 90s'. With better understanding on the importance of patient selection[5, 6] and with the modification of technique, SDR is considered safe and effective in permanent tone reduction. First pilot local data was available in 1999[7] and a recent study reported improved bladder function in a significant proportion of children with spastic cerebral palsy after SDR.[8] A local study also reported improvement in short term functional outcome after SDR.[9] Intrathecal Baclofen had been tried in the past decade but is not yet widely available in Hong Kong.

The concept of single event multilevel surgery (SEMLS) has significant impact on the orthopaedic care in children with cerebral palsy. It comprises muscle lengthening or transfers and correction of bony alignments or joint deformities in a single surgical session. It is planned to aim at various levels in one goal and preferably at a later age, saving patients' time but required expertise in planning on the timing and extent of the surgery. Its intermediate term effect on the improvement of gait was well established.[10]

The use of 3D Instrumental Gait Analysis[11] is used as an objective tool to help decision making and monitor treatment progress especially in surgical interventions. There are a number of gait laboratories in Hong Kong. Examples of two fully equipped gait laboratories for children in Hospital Authority (HA) are at Duchess of Kent Children Hospital (DKCH) and Tuen Mun Hospital (TMH). Some other laboratories are stationed at universities and are mainly for research purpose. The more recently developed rehabilitation aid like robot-assisted locomotor training[12], is currently available and is going to be a standard rehabilitation equipment at physiotherapy departments of HA hospitals.

Service for Children with Cerebral Palsy: The Role of Child Assessment Service

Child Assessment Service (CAS) of the Department of Health provides comprehensive assessment services for children and families with special needs since 1977. One of the subspecialties in CAS is the Physical Neurorehabilitation (PNR) team. The team serves children with physical impairments in which cerebral palsy is one of them. Team members include Developmental Paediatricians, Physiotherapists, Occupational Therapists, Clinical Psychologists, Speech Therapists, Social Workers and Nurses. The team provides assessment on the patient's cognitive, physical and functional levels and to look for any associated impairments. A rehabilitation and educational plan is then formulated. Assessments are based on functional approach according to the International Classification of Functioning, Disability and Health Model (ICF).[13, 14] (Figure 1) For patients with communication difficulties whom might benefit from Augmentative and Alternative Communication (AAC), our AAC team will be involved to assess for the need of aided communication.

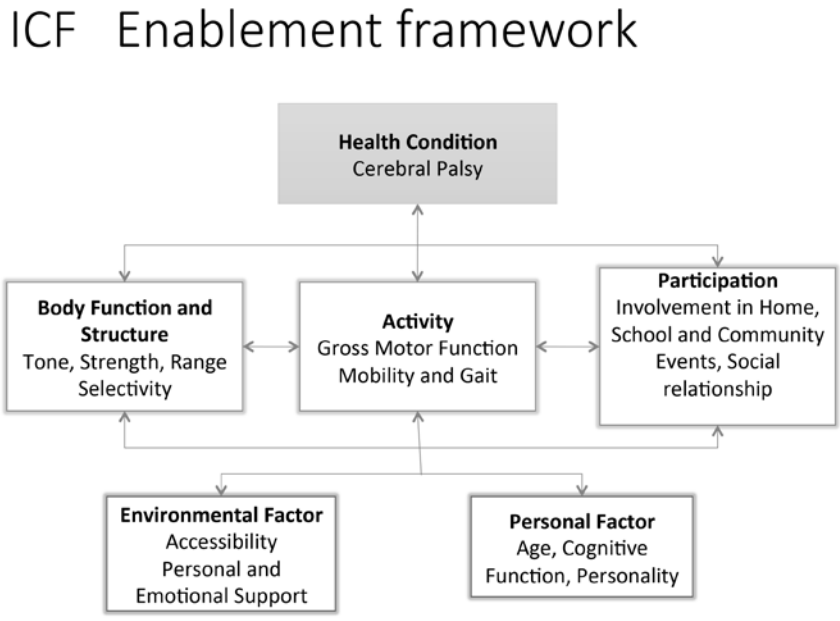

Figure 1: International Classification of Functioning, Disability and Health Model (ICF) in the context of cerebral palsy
Activity assessment include:
Gross Motor Function Classification System (GMFCS) and Functional Mobility Scale (FMS)
Manual Ability Classification System (MACS)
Communication Function Classification System (CFCS)

Collaborative Work between Sectors: Joint Clinic Program

As the problems encountered by children with cerebral palsy is complex and diverse, one single specialty would not be able to provide services for all their needs. The idea of having a conjoint clinic specifically serving these children was then developed. The first conjoint clinic named the Selective Dorsal Rhizotomy Clinic (SDRC) was first established in 1997 as a joint venture between CAS and the Department of Neurosurgery, Tuen Mun Hospital (TMH). The aim of the clinic was to provide a platform for clinicians to share experience in the management of cerebral palsy and to discuss management plan for potential clients whom might benefit from SDR. Current members are Developmental Paediatricians and Physiotherapists from CAS, the Neurosurgeons, Physiotherapists, Orthopaedic Surgeons, Paediatricians and Urologists[15] from TMH. Preschool and school therapists and the main carer of the child are also important collaborators of the clinic. They often provide important information which might not be able to be retrieved in a usual clinic setting. In the clinic, the team also assesses and recommends interventions if SDR is not the best option. With the availability of instrumental gait analysis, objective data are now available to assess patients before and after Botulinum Toxin injection, SDR or Orthopaedic surgery. The clinic also has regular reviews for post-SDR clients for continual care and serves to facilitate future screening, rehabilitation recommendations and looks for long term data and outcome.

With time, the Kowloon Physical Rehabilitation Clinic (KPRC), another conjoint clinic stationed in Kowloon, was established in 2009. Held in the Central Kowloon Child Assessment Centre, the clinic aims to serve patients with cerebral palsy or other physical conditions living out of Tuen Mun. It is also for easier access for some of the referrers. Approximately 30 patients were seen each year in the two conjoint clinics which were held once every three months. The clinics also invited overseas experts to join in as a platform for learning and advice concerning rehabilitation needs for clients with complex rehabilitation needs. (Figure 2)

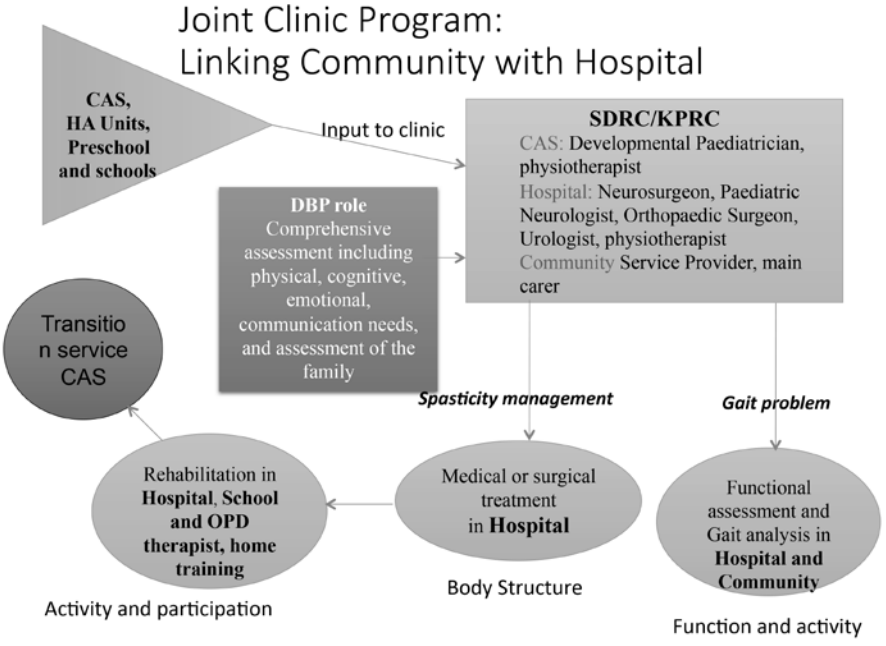

Figure 2: Joint Clinic Program flow chart
DBP: Developmental Behavioural Paediatrician
OPD: Out-patient Clinic

Appendix 1: Some local resources for transition service in Hong Kong

http://www.swd.gov.hk/en/index/site_pubsvc/page_rehab/sub_listofserv/id_serphyhandi/

- Sheltered Workshop (SW)
- Supported Employment (SE)
- Integrated Vocational Rehabilitation Services Centre (IVRSC)
- Integrated Vocational Training Centre - Day (IVTC-Day)
- On the job Training Programme for People with Disabilities (OJT)
- Sunnyway - On the Job Training Programme for Young People with Disabilities
- Work Extension Programme (WEP)
- Financial Incentive Scheme for Mentors of Employees with Disabilities Receiving Subvented Vocational Rehabilitation Services
- Support Programme for Employees with Disabilities

Transition Service:

It is well established that gross motor function improves in all children with cerebral palsy up to the age of 7 years, reaching a plateau till adolescence. They might experience deterioration in function thereafter.[16] In our experience, quite a number of patients on reaching their early adulthood had already defaulted all medical follow up for different reasons. Apart from medical needs, they also face psychological, social, educational and vocational challenges. In the community, the schools for students with physical handicaps provide excellent transition to adulthood. But for those studying in mainstream schools, there is a wide medical and therapy service gap. Owing to the above, CAS had started transition service for children studying in mainstream school with cerebral palsy and other physical challenges since 2012. The clinic aims to provide medical, psychological, educational, social and vocational supports for these young people and by linking services available in Hong Kong. (See Appendix 1)

What are The Next Steps for Children with Cerebral Palsy in Hong Kong?

1. ***Hong Kong Children's Hospital***

   Hong Kong Children's Hospital (HKCH) is expected to commence service operation by phases in 2018. In the view of services for children with cerebral palsy, we hope the HKCH can function not only as a centre for professionals from different organizations to offer their expert services, but also serve as a platform for knowledge exchange and further development of services for children with physical impairments.

2. ***Paving the Way to Independence in Adulthood***

   The first decade of a child with cerebral palsy is relatively well served by various developed services. The many decades of years of adulthood will rely on the determination and support to reaching and maintaining independence of an individual. How to prepare a child to be able to take care of his or her own physical, psychological and emotional health and independent living requires further dedicated efforts from different services.

3. ***Working with Mainland China***

   The proximity and special relationship of Hong Kong to the vast populated China create an immense demand for the development of various specialty services. Collaborative work including knowledge and skill sharing with medical and rehabilitation worker in China could benefit a large population of children with cerebral palsy. At present, there exists a special need for creative services and support systems for the group of children born in HK but live with their parents in China.

Conclusion:

The care for children with cerebral palsy requires conjoint effort from different service providers such as the hospitals, CAS, schools and NGOs. Experience from the CAS conjoint clinics for children with cerebral palsy demonstrates the effectiveness of coordination and

integrated care plan for our patients. Through the teamwork of experts from different fields with the referrers, schools, primary health care providers and care takers, and through the platform provided by established clinics, excellent communication and positive synergistic outcomes have been gained.

Breaking boundaries and joint efforts are essential for achieving the best support to our children in need. We hope that our experience not only helps to improve the care provided to children with cerebral palsy, but may also serve as reference for work with other children with complex needs.

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Chemodenervation for Focal Spasticity in Cerebral Palsy

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Introduction

Spasticity is defined as an upper motor neuron syndrome characterized by velocity dependent increase in muscle tone resulting from hyperexcitability in the stretch reflex.[1] Together with associated weakness and poor motor control, spasticity contributes to significant functional disability to the child with cerebral palsy (CP). The goals for tone reduction treatment include functional improvement, ease of care, and prevention of secondary pain, contractures and orthopaedic problems. In setting treatment goals, the physician should go beyond ordinary clinical assessment and think in the context of the child's activities at home and school, as well as interests and recreation.[1] For example, over enthusiastic treatment of lower limb spasticity may affect the child to maintain erect posture.[1,2] Successful treatment relies on comprehensive evaluation of the pattern of body part involvement, muscle tone assessment, motor function and performance. Different modalities of treatment, including oral antispasticity medications (e.g. baclofen, diazepam, dantrolene sodium), continuous intrathecal baclofen infusion (ITB) and selective dorsal rhizotomy (SDR) are utilized to tackle focal and generalized spasticity.[1,2] This article focuses on the current evidence and practice in chemical denervation for focal spasticity.

Perineural Injection of Phenol

Chemodenervation refers to interruption of nerve-muscle transmission with an injectable agent. At Caritas Medical Centre, we employ two injection strategies, namely perineural injection of phenol and intramuscular injection of botulinum A toxin (BoNT-A). We utilize phenol at a concentration of 6% aqueous solution for perineural injection, resulting in axonal degeneration. The target nerve is identified with electrical stimulation. Sedation is often required in Paediatric patients. In the functional limb, the volume of injection can be titrated to eliminate spasticity while retaining desirable function. In nonfunctional extremities, more extensive neurolysis may be employed to facilitate hygiene care and comfort. For example, we often target the **musculocutaneous** nerve and obturator nerve to alleviate severe elbow flexion and hip adductor spasms in quadriplegic patients. Other sites include the posterior tibial nerve denervation for equinus and motor point injection over pectoral muscles to alleviate shoulder adduction spasms. Unlike BoNT-A, in our experience the onset of denervation effect after phenol block is quite instant. The effect is not permanent; clinical benefit varies from a few weeks to nearly one year.[1] Caution should be made when targeting a mixed motor and sensory nerve, which carries a significant risk of pain and paraesthesia. Compared to BoNT-A injection, phenol nerve block is technically demanding, but does not have immunogenic problem and the agent is of much lower cost.[1]

Intramuscular Injection of Botulinum Toxin A

Botulinum toxin is an exotoxin produced by Clostridium botulinum. Therapeutic injection into muscle inhibits synaptic release of acetylcholine, resulting in chemical denervation and focal paralysis.[1, 3] Of the eight immunologically distinct serotypes, serotypes A and B are commercially available. BoNT-A is marketed under the trade names of Botox, Dysport and Xeomin. As the potency of a single unit varies greatly among different commercial types and there is no simple inter-brand dose exchange equivalence, it is important to specify the commercial brand in prescribing dosing units.[1, 3] As the therapeutic effect of the toxin relies on the presynaptic uptake of motor endplate at the neuromuscular junction, injections need to be given to the motor endplate region.[4]

BoNT-A has been used extensively for cortical spasticity for nearly two decades. It is effective to improve the range of motion, reduce spasticity, and improve gait pattern.[4] Recent evidence supports an integrated multilevel treatment approach, in which multiple muscles are injected within a single session. Instead of a standardized total dosage, standardized dosage per muscle group is utilized for dose calculation. The latter is dependent on the muscle volume, the amount of spasticity and the involvement of the particular muscle in the overall pathological gait pattern.[4] In the NICE guidelines 2012, BoNT-A may be considered if the focal spasticity impedes fine motor function (upper limbs) or gross motor function (lower limbs), compromises care and hygiene, causes pain or sleep disturbance (lower limbs), impedes tolerance of other treatment such as orthoses, or causes cosmetic concerns to the child or young person. In addition, BoNT-A may be considered in rapid-onset spasticity or focal dystonia causing postural, functional difficulties or pain (focal dystonia). BoNT-A should not be given if the child has severe muscle weakness, history of adverse reaction or allergy, or is receiving aminoglycoside treatment.[5] Recent international consensus statements review randomized controlled trials of BoNT-A therapy in CP children, and formulate appropriate treatment recommendations for the lower limbs and upper limbs respectively. Areas without high levels of evidence, including assessment, outcome measures, adjunctive therapies, recommended doses, dilution, muscle localization techniques and screening for adverse events are also reviewed. Recommendations are summarized in Tables 1 and 2.[3, 6]

Table 1: Treatment recommendations of BoNT-A for lower limb spasticity

Choice of assessment tools
Need to reliably differentiate spasticity from fixed contractures and other causes of hypertonia (level U); • Modified Tardieu Score and Australian Spasticity Assessment Scale to quantify spasticity
Document GMFCS and baseline functioning such as care needs and gait (level U);
For ambulant children: describe gait and function using appropriate scales ± video recording (level U); • Instrumental gait analysis is the most objective measure of gait, but its use is largely limited to research context. • Observational gait analysis and gait classifications are recommended for routine clinical use.
For non-ambulant children: describe abnormal postures and care needs (level U).
Optimal treatment regimen
BoNT-A is established as effective in the management of spastic equinus to improve gait (level A);

Serial casting is at least as strong as BoNT-A in the management of spastic equinus (level U);
Injections to the adductors is probably effective in some areas of goal attainment (level B);
Injections to the adductors are not effective to improve gross motor function in CP children, but may help delay hip displacement in the short term (level A);
Injections to multiple lower limb muscles have inadequate and conflicting data in respect of gait, goal attainment and function (level U).
Injection protocols, dose and injection site
Conversion factors between different preparations of BoNT-A is strongly discouraged (level A);
Dose determination relates to severity, treatment goals, muscle size, and previous treatment response;

Product	Recommended dose	Maximum Total Dose
BOTOX	GMFCS I-IV without risk factors: 16-20U/kg GMFCS V with risk factors: 12-16U/kg (level U)	<400-600U
Dysport	20U/kg (level B)	<900U

Cautious with GMFCS level V and any patient with breathing problems or dysphagia;
Injection interval for serial injections should generally be no less than six months;
Precise localization of muscle injection sites helps to reduce unwanted toxin migration (level U).
Traditional identification by palpation and anatomical landmark is inaccurate except for the gastrocsoleus. Electrical stimulation is uncomfortable. Ultrasound emerges as the preferred method for localization, with the advantages of being pain-free, quick, and supports real-time visualization of BoNT-A spread, as well as estimation of muscle size and fibrosis.
Adjunctive interventions
Serial casting should follow BoNT-A for management of fixed calf contracture (level U);
AFOs help to improve gait and protect foot integrity (level U);
Prolonged stretching assists in management of muscle length (level U);
Strengthening and target motor training are essential adjunctive when goals to improve motor function are identified (level U).

Table 2: Treatment recommendations of BoNT-A for upper limb hypertonia

Assessment*
Determine the subtype of hypertonia;
Assess the hypertonia severity & passive range of motion at the muscle/ joint level;
Classify the upper limb function and determine the functional impact of hypertonia;
Occupational assessment to determine the functional goal of BoNT-A injection.
Indications
Functional improvement: <5 years*;, mild to moderate spasticity*; active movement and adequate grip strength; able to participate in intensive programme; motivated & supportive family.
Symptom management*: Moderate to severe spasticity; fixed contracture; tolerate casting or splintage programme.
Precautions
Informed consent about potential risks: Transient (2-3 weeks) localized weakness in grip strength; Systemic overflow (dysphagia, dysphonia, systemic weakness respiratory distress) one day to several weeks post-injection.

Dosage, dilution & reinjection interval
Do not use conversion factors between different preparations;
Caution in patients with dysphagia or breathing problems;
For functional improvement (minimize diffusion beyond the target muscle), the dosage should be distributed in small amount of normal saline in the muscle at 1-2 injection sites;
Interval > 3months and extended as far as clinically justifiable.
Localization techniques
Palpation inadequate. Use techniques that allow proper identification of muscles (ultrasound or electrical stimulation)*;
Analgesia ± sedation to reduce pain.
Reviews*
Clinical review in 1-3 weeks;
Structured review at 4-6 months;
In children with good response, further injection considered at 6-12 months.

***Expert opinion**

Conclusion

Treatment of spasticity in CP children is challenging, and requires multi-disciplinary input for optimal outcome. While every case is unique, in general orthopaedic surgery should be delayed until the gait is mature.1 Meanwhile, the range of motion should be maintained by physical therapy and proper splinting. Spasticity may be managed by oral medications, BoNT-A injections, casting, ITB and SDR as indicated. Towards gait maturation at ages 6 to 10 years, instrumental gait analysis can be used to aid decisions for orthopaedic interventions.[1]

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Neurosurgical Intervention for Children with Spastic Cerebral Palsy

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Introduction

Cerebral palsy (CP) is a neurological condition encompassing a group of motor disorders that cause physical disability in developing children. CP is caused by a non-progressive damage to the motor control centers of the developing brain and can occur during pregnancy, during labour or after birth up to the age of three. The incidence of CP is around 3 per 1,000 live births. In a local study, the overall prevalence was 1.3 per 1000 children[1].

Spastic CP is by far the commonest type of cerebral palsy, accounting for 70% to 80% of all cases. Spastic CP is classified according to the region of the body affected. In spastic diplegic patients only the lower extremities are involved. In spastic quadriplegia, all four limbs are involved. Spasticity is a movement disorder characterized by a velocity-dependent increase in tonic stretch reflexes. Children with spastic CP have a neuromuscular mobility impairment stemming from an upper motor neuron lesion in the brain over the areas in the motor cortex or the cortico-spinal tract, which descends in the spinal cord, in the lateral columns and carries signals for voluntary movement of skeletal muscles. The damage impairs the capability of nerve receptors at spinal levels to response to gamma amino butyric acid, leading to hypertonia in the muscles innervated by these damaged descending tracts.

In spastic CP patients, they have signs and symptoms of upper motor neuron syndrome. The motor disorder in these children is complex, and is the result of a number of factors like muscle weakness, paucity of active movement, inability to perform selective fine movement, brisk tendon jerk reflexes and incoordination. There are usually co-contraction of agonists and antagonists muscles and excessive spreading of reflexes to other muscle groups. Consequently, their muscles have reduced dexterity, weakness and fatigability, which will translate into defective daily activities. Deformities of the bones and joints of the limbs are common after prolonged muscle imbalance and spasticity.

About 10% of CP patients are classified as dyskinetic CP but some of them have mixed forms with spasticity and dyskinesia. The culprit falls on the damages in the basal ganglia and/or the pyramidal tract. Kernicterus is associated with this type of CP. Dystonia is prominent in dyskinetic CP and is defined as a “movement disorder in which involuntary sustained or intermittent muscle contractions cause twisting and repetitive movements, abnormal postures, or both.” Dystonia may cause hypertonia and hypotonia.

In contemporary clinical practice, the management of CP patients requires a multi-disciplinary approach. We have to mobilize and engage the parents and caregivers at the very early stage. All parties are involved in the selection of the most appropriate treatment modality for the patient. The team must be able to understand and have similar anticipations for what might be achieved by interventions. The real goals of treatment are not simply to reduce tone or improve range of movement, but also to improve motor function, increase mobility, increase independence, decrease discomfort and for easier care. The multi-disciplinary management team must be well equipped and familiar with and prepared to discuss the pros and cons of the various options available.

Present-day treatments for spasticity and hypertonia include oral muscle relaxant medications, physiotherapy, orthotic devices, and repeated intramuscular injections of botulinum toxin. Invasive neurosurgical intervention would include selective dorsal rhizotomy (SDR) and continuous intrathecal baclofen infusion (ITB). The spectrum of therapeutic interventions ranges from diffuse to focal, temporary to permanent. A team approach is mandatory because these patients often require different treatment modalities at different ages and stages of the disease. In general, stretching exercise, splints and physiotherapy are prescribed for patients at age of 2-3. Botulinum toxin injections, casting and orthosis would be added at age of 3 to 5. SDR is usually performed at the age of 6-7.

Neurosurgical Intervention

Selective Dorsal Rhizotomy SDR

SDR is a neurosurgical procedure performed in patients suffering from spastic cerebral palsy. The selective de-afferentation of sensory nerve rootlets from L1 to S1 results in a reduction of contracting stimuli to muscles resulting in a decrease in hypertonia and spasticity. A number of case series suggested that selective dorsal rhizotomy reduces spasticity substantially, improves ambulatory function, and involves no unacceptable short-term risk when performed by experienced multidisciplinary teams[2-4]. The effects of SDR are permanent over the lower limbs.

The Selective Dorsal Rhizotomy (SDR) Clinic in Tuen Mun Hospital was established in 1997. The team members include physiotherapists from the hospital, special schools and Child Assessment Service of the Department of Health, paediatric neurologists and developmental paediatricians, orthopaedic surgeons, neurosurgeons and urologists. The clinic provides a platform for multidisciplinary approach to spastic CP patients, their parents and caretakers. The clinic provides screening and assessment to select potential surgical candidates for SDR. We also provide them with pre-operative training program and peri-operative rehabilitation protocol. The families have to understand and be committed to the important pre and post operative physiotherapy training, which will last for 4-6 months before a decision on SDR is made. We usually recommend the neurosurgical procedure when we witnessed plateauing response in a spastic patient undergoing continuous vigorous physiotherapy with or without botulinum toxin injection.

SDR is a functional neurosurgical procedure with the purpose of improving lower limb function. We have adopted a series of tools and examinations for the monitoring and documentation of the clinical progress. Main outcome measures include Modified Ashworth Scale, passive range of joint movement, the Gross Motor Function Measure, the Paediatric Evaluation of Disability Inventory, the Canadian Occupational Performance Measure, urodynamic study, oxygen consumption and three-dimensional gait analysis. We schedule the test immediately before SDR, six months, and twelve months and up to six years after SDR.

We have adopted selection criteria for spastic diplegic and quadriplegic patients. The selection criteria for Spastic diplegic patients for SDR include:

1. Spastic - Spasticity of the lower limbs interfering normal functions, disturbing fluidity of gait or movement.
2. Strong - Fair to good lower limb muscle strength and control
3. Straight - Fair to good trunk control with no fixed orthopaedic deformity
4. Slim - Not too heavy or obese
5. Smart - Normal to near normal intelligence
6. Social support - A supporting and motivated family

The selection criteria for Spastic quadriplegic patients for SDR include:

1. Significant lower limb spasticity interfering with positioning and care
2. No severe dystonia
3. No fixed contracture at multiple joints

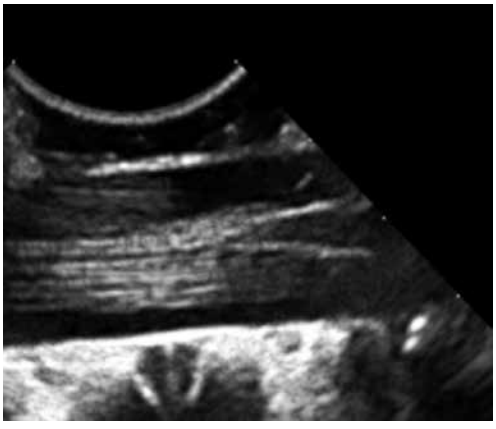

Photo 1. Using ultrasound to locate the conus medullaris after making a small laminectomy

SDR is performed by doing a single or two levels laminectomy at the level of conus medullaris usually at L1-2. After laminectomy, the surgeon will open the dura and arachnoid at the midline. Dorsal roots are exposed as they come out at two sides of the V shape end of the conus medullaris. The dorsal roots will be separated from the anterior motor roots by using Paul's drain. The dorsal root will be further subdivided into 4-5 rootlets and their clinical response to electrical stimulation tested. Abnormal rootlets will be cut. The procedure will be performed on L1 to S1 dorsal roots on both sides[5].

The term "selective" is used because we rely on the Intra-operative Trigger Electromyography (EMG) response to find the rootlets causing abnormal muscle spasms before cutting them. We insert paired needle electrodes into the deltoids, hip adductors, vastus medialis, hamstrings, gastrocnemius and the external anal sphincter for EMG monitoring during SDR. A pair of active electrodes is used to stimulate individual rootlet during surgery. The EMG criteria for selecting an abnormal nerve rootlet include:

1. Low stimulation threshold
2. A tetanic or polyphasic to a tetanic stimulation of a 50Hz chain lasting for one second
3. A spread of EMG response to the contralateral side

We use EMG as a guide but also the on-table clinical response during dorsal rootlet stimulation as selection criteria. It has been observed that according to the segmental innervation of the lower limb, the higher the muscle tone, the more extensive the dorsal root cutting would be. In general, 33-50% of the rootlets would be cut during SDR.

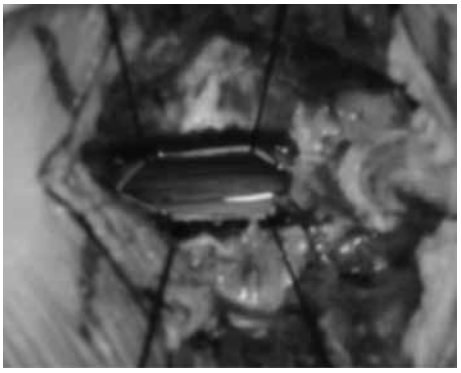

Photo 2. Dura opened in the midline exposing the conus medullaris and the dorsal roots

In the first two post-operative days, the patients are nursed on lateral position and turned every 2 hours. The Foley's catheter is removed on day 3. Patient are mobilized on day 4 Both patients and parents will participate in intensive physiotherapy program from day 4 onward and as outpatients in the following two months after discharge at day 10.

We have performed over eighty SDR procedures since 1997. 80% of the surgical candidates belong to the spastic diplegic group and 10% belong to the spastic quadriplegic group. 75% of them had surgery done before the age of nine. There was no major surgical complication. However, wound pain and postoperative low-grade fever were fairly common, usually lasting a few days and improved after acetaminophen. There was no wound infection, cerebral spinal fluid leak or pseudo-meningocoele after surgery. A small proportion of them developed dysuria after surgery but no urinary tract infection was found. Around 20% of the SDR patients complained of some degree of lower limb numbness that usually resolved after a few days to weeks.

We observed that the reduction of lower limb muscle tone was long lasting. The patients have no recurrence of lower limb spasticity after surgery for a mean follow up of 6 years. We found that these patients experienced substantial reduction in spasticity after SDR, as documented by a marked reduction in Modified Ashworth Score of the lower limbs when the baseline Modified Ashworth Score was compared with findings 12 months after SDR. There was significant improvement in combined hip abduction range with the knee in extended position (R2) and in selective control scoring. The patients exhibited significant improvement in Gross Motor Function Measure total score and in dimensional scores in crawling, kneeling, walking, running, and jumping after selective dorsal rhizotomy plus physiotherapy. Improvements in walking were also reflected by significant improvements in Observational Gait Scores. Changes and improvement in instrumental gait analysis and oxygen consumption were also observed[6, 7]. Patients usually developed transient lower limb weakness after SDR. The weakness might last for 4-8 weeks and the GMFM also dropped during this period of time. In all patients, the weakness recovered after physiotherapy and training. Most of them showed improvement in GMFM after two to three months of intensive physical therapy.

There was no long-term complication such as spinal deformity. The progression of hip joint pathology was in accordance with their hip migration index right before SDR. Subluxed hips found before SDR cannot be salvaged by the procedure. Majority of patients with stable hips remained so after surgery. Hip surveillance with repeated hip X rays may help identifying patients for SDR, as a deteriorating migration index is a signal for early intervention.

There was no deterioration of sphincter function seen in long-term follow up. Around 50% of our surgical candidates have abnormal urodynamic study such as detrusor instability and hyper-reflexic bladder before SDR. Only one patient reported increase in frequency of urination after surgery. About fifty percent of patients with detrusor instability, as confirmed by a pre-SDR urodynamic study, demonstrated improvements in their urinary symptoms and signs after SDR. This finding has been verified in patients with repeated urodynamic studies.

Intrathecal Baclofen Infusion (ITB)

We use oral Baclofen to reduce limb spasticity by its effect on GABA receptors, oral baclofen has a limited effect on spasticity simply because the drug cannot go through the blood brain barrier and cannot achieve a therapeutic concentration at the receptor sites in the spinal cord. But if we infuse baclofen continuously into the spinal canal, the concentration of baclofen achieved are much higher than those present after oral administration and this would lead to a much greater therapeutic effect. In addition to an effect on spasticity, baclofen also improves dystonia. The site of action of baclofen in the treatment of dystonia is thought to be supra-spinal. There is good evidence that ITB reduces the severity of generalized dystonia in patients with dystonic or spastic/dystonic CP[8]. The reduction in dystonia was associated with improved quality of life and ease of care.

Photo 3. Dorsal root exposed and is ready for SDR

The most commonly used infusion device is the programmable Synchromed device (Medtronic, Inc., Minneapolis, MN). This is a battery-powered pump that can be adjusted using a radiofrequency-controlled external wand and programming computer to deliver variable flow rates so as to prescribe a preset dose of drug into the spinal canal. Potential candidates usually undergo a trial of bolus baclofen injection by lumbar puncture to confirm a positive effect in reducing hypertonia before implantation of the pump. The pump is implanted into a subcutaneous or subfascial pocket in the anterior abdominal wall under general analgesia. A catheter is inserted into the lumbar subarachnoid space at the L3–4 or L4–5 level, and is directed superiorly to place the tip at approximately T10– 12 for spastic diplegia, C5–T2 for spastic quadriparesis, or C1–4 for generalized secondary dystonia[9].

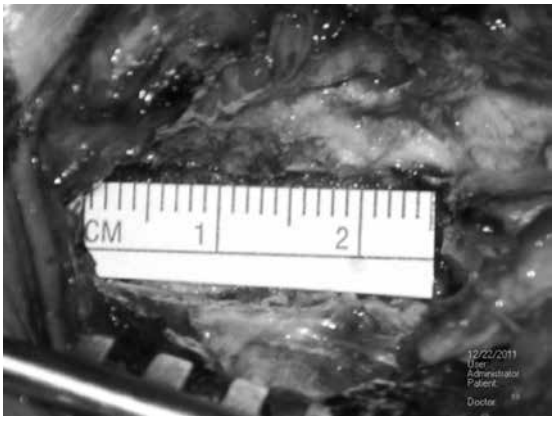

Photo 4. Size of the exposure provided by L1-2 laminectomy

The use of ITB is not without risk. The risk can be related to the drug, to the surgical procedure or the hardware. The most common drug related problem is mild sedation, which requires a dose reduction. Patients may experience dizziness, blurred vision, and slurred speech. Increased frequency of seizures has also been reported. Unfortunately, there are Life-threatening events reported which was related to overdoses or sudden drug withdrawal. Overdoses are characterized by severe respiratory depression, coma, hypotension, and bradycardia. The diagnosis is supported by the findings of weakness, flaccidity, and areflexia in both lower and upper limbs. Lumbar puncture and drainage of the intrathecal baclofen and supporting care till the drug effects wear off are the treatment options.

Sudden withdrawal of ITB after long-term use may result in confusion, hallucinations, psychotic behavior, rebound severe spasticity, seizures and hyperthermia. Oral baclofen or benzodiazepines may be given in early stage, and oral dantrolene can be used to prevent or treat hyperthermia. Restoration of baclofen infusion into the subarachnoid space by lumbar puncture or as a bolus through the pump may reverse the symptoms.

Photos 5. The Medtronic SynchroMed infusion pump, catheter and the programmer

Pump and catheter related complications like kinking, disconnection at a connector site, displacement of the intrathecal catheter and leakage of CSF at the catheter insertion site. The catheter related complications are reduced with improved catheter systems design, in particular the development of thicker-walled catheters. Meticulous training of the surgeons before the procedure also contributed to the reduced complication rate. Implant related infection is another major concern. Local infection of the wound or subcutaneous pump pocket has been reported in up to 20% of patients. Pump erosion through the skin and subsequent contamination of the device is not unusual especially in the thin spastic quadriplegic children. With the use of systemic antibiotic local infections can sometimes be eradicated, unfortunately more often the pump has to be removed.

The other obstacles on ITB utilization are the high cost of the implant, the expensive baclofen and to maintain an ITB patient care program. The families and patients have to face the possibilities of reoperation and to keep on the life long painstaking and labour intensive

drug-refilling program. We recommend the use of ITB only in selected spastic quadriplegic or dystonic CP children with disabling spasticity or hypertonia.

Conclusion

We advocate multidisciplinary approach for the management of spastic CP patients. The team should involve physiotherapist, occupational therapist, developmental paediatrician, paediatric neurologist, orthotics, orthopedic surgeon, and urologist in addition to the neurosurgeon. The team should appreciates the various neurosurgical and non-neurosurgical interventions available for the relief of spasticity and recognizes the goal of treatment. We adopted the International Classification of Function (ICF) framework and always stress the importance of participation and improvement of functions as the therapeutic goal. The team, which also includes parents or caregivers, set up the best individualized management option to heighten the outcome. The response to the treatment or the progress after neurosurgical procedure should be carefully monitored. We observed that after tone reduction or normalization, patients require the input of orthopaedic surgeons to work on the soft tissues and/or bone in order to improve the joint alignment. This fine tuning process is for the betterment of the gait or lower limbs function.

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BRAINCHILD
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Orthopaedic Management in Children with Cerebral Palsy

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Background

The prevalence of cerebral palsy (CP) in children is estimated to be 1.3 per 1000 children in Hong Kong[1]. These children develop movement disorders as a result of the brain insult during prenatal (e.g. maternal infection), perinatal (e.g. anoxia) or postnatal period (e.g. meningitis). They are in general classified according to the physiological (e.g. spastic, hypotonic, dystonic and athetoid) or geographic (monoplegic, diplegic, paraplegic and tetraplegic) involvement.

CP is a neurological disease. Unfortunately, the neurological damage is irreversible. Depending on the severity of the brain insult, the damage of the cognitive and motor function in these children can vary. It is usually difficult to be certain about the ultimate ability of these children when they are very young. Therefore, repeated assessments are important. It is also important to set reachable treatment goals, at different stages, according to the cognitive and motor development of these children with the caretakers to avoid unrealistic expectations.

The ultimate ability for the children with CP to ambulate depends on the extent of neurological deficit and its geographic involvement[2]. There are some poor prognostic indicators that may suggest the involved children may not be able to ambulate ultimately. These include persistence of infantile reflexes beyond 15 months[3], lack of head control by 20 months[4], and inability to sit by 24 months. Even if the children with CP eventually become ambulatory, it is usually delayed. For example, children with spastic hemiplegia generally walk between ages 18 and 21 months; whereas, spastic diplegic walkers may start walking by the age of 4. However, their walking abilities usually plateau by the age of 7.

One should remember, "the child with cerebral palsy becomes the adult with cerebral palsy". Therefore, treatments should begin very early and the goal is to maximize their function. Orthopaedic interventions can help to reduce joint contractures, and to correct deformities in order to improve their function. Among different types of CP, orthopaedic intervention is more beneficial for patients with spastic CP because of more predictable results.

Children who suffer from spastic CP will have increased muscle tone due to hyperexcitability of the myotonic reflex arc. Together with the poor selective motor control, these primary abnormalities will drive the development of secondary deformities in the muscle (e.g. hamstring and gastrocnemius contracture) and in the skeleton (e.g. excessive femoral anteversion and external tibial torsion)[5]. It is not uncommon to see patients with spastic CP developing scoliosis, hip adduction contracture, windswept deformities, knee flexion contracture, and rocker bottom foot deformities. The patients will have problems with mobility and poor posture as a result of these deformities.

The magnitude of spasticity changes as the patient matures. Usually the spasticity is the most severe at 4 years of age and gradually reduces up to the age of 12[6]. Therefore, it is crucial to monitor the effects of the spasticity on the development of these children. Various treatment modalities have been used to reduce the spasticity in patients with spastic CP. Botulinum Toxin A (Botox) and baclofen are commonly used medical therapies and selective dorsal rhizotomy is very effective surgical method in reducing spasticity. Despite all these interventions, orthopaedic surgical interventions are quite often needed for the management of gait abnormality, hip instability, joint contractures and foot deformities[7-9].

Assessment for Children with Cerebral Palsy

The assessment of the children with CP can be sometimes difficult especially if they are not cooperative. It is important to assess the children repeatedly and regularly so that accurate information can be obtained. A multidisciplinary team including doctors, physiotherapists, and occupational therapists, is needed. Gross Motor Function Classification System (GMFCS) is a commonly used classification to help classify the disability of the children with CP. It was first used for children from age 12 months to 12 years based on the observation of a child's self movement and need for assistive technology and or wheeled mobility[10]. The GMFCS was revised, expanded and further validated to include children up to the age of 18[11]. The GMFCS has five levels in which level I children can walk and run independently; whereas, level V children have very limited voluntary movement. GMFCS is a very useful treatment and prognostic guide for managing CP children[12-14]. In general, orthopaedic surgery aims for gait modification for level II and III children and postural improvement for level IV and V children.

Orthopaedic Surgery for Spastic Cerebral Palsy Patients

The role of the orthopaedic surgeries in spastic CP patients is to (1) reduce the effect of the spasticity of the muscle and (2) correct secondary bony deformities. The surgery should help to improve the walking ability for the potential walkers and sitting posture for the sitters. The indications of the surgeries have to be set clearly with the parents and caretakers before the surgeries in order to avoid any unrealistic expectation and misunderstanding. Different bony and soft tissue surgeries have been described in managing spastic CP. The choice of the surgery depends on the severity of the spasticity, selective motor control, age, pattern of the paralysis and types of deformities. The treating surgeons should be aware of the limitation of the patients and set reachable goals for them.

Modern Gait Analysis

For GMFCS II-III, the aim of the orthopaedic surgery is for gait improvement. Careful analysis of the abnormal gait pattern is very important. Apart from careful clinical examination, more detailed quantitative information can be acquired using computer-based gait analysis. Such motion analysis consists of 3-dimensional measurement of motion (kinematics), measurements of moments and power in the articulations of the lower limbs (kinetics), electromyography, dynamic foot pressure (pedobarography) and oxygen consumption measurement. It helps the clinicians to understand the interaction of the selective motor control, balance and spasticity of the patients during walking. More importantly, the effect of the secondary changes such as the lever-arm dysfunction of the lower limbs as well as the tertiary changes e.g. compensatory or coping mechanism for the primary and secondary abnormalities can be clearly delineated. The records can also be used for monitoring the progress of the disease as well as the outcome of the surgery.

Timing of Surgery

In the past, CP children were commonly treated surgically every year until they reached skeletal maturity. Tendon lengthening was one of the most commonly performed surgeries. Due to repeated hospitalization and prolonged immobilization, such "birthday surgery" is not very welcome nowadays. Today, single-event multilevel surgery (SEMLS), addressing all concomitant joint contractures at a single surgery, is advocated. Since the abnormality of one joint also affects the position of other joints, SEMLS corrects all the related deformities at one surgery and helps shorten the rehabilitation period. This also avoids repeated hospitalization and overcorrection of the abnormalities. Since the skeleton continues to model when the children grow, secondary changes such as contractures and bony deformities do not become apparent until they are older. It is therefore advisable to defer any gait modification surgery until the children are relatively older and the deformities are more apparent e.g. after the age of 7. However, in situations like progressive hip subluxation[15,16] or severe joint contracture limiting the original walking potential in some children, early soft tissue release should be considered before the deformity progresses further.

Gait Modification Surgery

The parents should be aware that gait modification surgery can change the gait pattern of their children but not to make it normal. Identifying common gait abnormalities, recognizing their causes and understanding the interaction between the soft tissue and bony abnormalities are the keys to success in gait modification surgery. The biarticular muscles are more commonly affected in spastic CP patients e.g. rectus femoris, hamstrings and gastrocnemius. Different degree of involvement to these biarticular muscles can result in very different gait patterns[17]. The key is to identify these gait patterns and tackle the underlying problems accurately. There are four common gait abnormalities of the knees in CP patients - jump knee, crouch knee, stiff knee, and recurvatum knee patterns[18]. Jump knee gait is quite frequently seen in spastic diplegic patients due to overactive hamstrings in the presence of tight or spastic gastrosoleus complex. Crouch knee gait can be related to the weakness or overlengthened triceps surae, external tibial torsion and or rocker bottom feet that

disrupted the normal ankle planterflexion knee extension couple. Stiff knee gait is caused by inappropriate phasic activitiy of the rectus femoris resulting in reduced knee flexion throughout the swing phase. Lastly, recurvatum knee gait is caused by spastic and contracted triceps surae with weakened hamstrings leading to hyperextension of the knee during the middle and late stance phase. Therefore, understanding the interaction of different muscles during walking is essential in the decision-making of gait improvement surgery.

Normal movement of a joint relies on the normal moment (M) of a muscle joint complex, which is the product of muscle force (F) multiplied by the lever arm (d). Lever-arm dysfunction in CP refers to the disruption of this moment generation because of abnormal development of the skeleton despite normal muscle force. In CP, the skeleton develops differently because of the abnormal forces acting onto it and very often results in shortened lever arm. Since moment (M) = F x d, the already weakened muscle force and shortened lever arm will produce ineffective moments. Depending on the site of the abnormal lever arm, the gait pattern will be affected accordingly e.g. coxa valga and excessive femoral anteversion will bring about ineffective lever arm at the hip leading to Trendelenburg gait. Five types of lever-arm dysfunction were described[5]: (1) short lever-arm (coxa valga), (2) flexible lever-arm (pes valgus), (3) malrotated lever-arm (external tibial torsion), (4) an abnormal pivot or action point (hip subluxation or dislocation), and/or (5) positional lever–arm dysfunction (crouch gait).

Abnormal moment of a joint can greatly affect the action of the neighbouring joints. This can be illustrated by the plantar flexion / knee extension (PF-KE) couple at the knee and ankle. With competent soleus muscle to slow down the forward momentum of the tibia in the stance phase, the ground reaction force is maintained in front of the knee. This generates extension moment at the knee without any additional action of the quadriceps. However, such PF - KE couple is disturbed in many spastic diplegic CP patients because of the weakened triceps surae and lever-arm dysfunction. The malrotated lever arm of the foot (external tibial torsion) and flexible level arm (breakage of midfoot and planovalgus foot) will cause the ground reaction force (GRF) to shift more lateral and posterior to the normal position. The already weakened or overlengthened triceps surae fails to control the progression of the tibia over the planted foot during the stance leading to excessive ankle dorsiflexion. The resulting GRF therefore shifts to the posterior aspect of the knee and brings about flexion moment of the knee.

Proper bracing can compensate some of these lever arm deformities. But the severe lever-arm dysfunction will require bony surgeries to correct them. Some of the procedures include varus derotational osteotomy of the femurs for coxa valga; derotation osteotomy of the tibia in patients with external tibial torsion; and foot stabilization surgeries for severe planovalgus foot can greatly improve the function of the patients.

Case illustration

Crouch Knee Gait

A 15 years old girl suffers from spastic diplegic CP. She develops crouch knee gait as a result of bilateral knee flexion contracture, hamstring contracture, excessive femoral anteversion and rocker bottom foot deformity. The gait analysis showed persistent knee flexion and increased ankle dorsiflexion during stance phase. She subsequently received bilateral proximal femoral derotation osteotomy, bilateral distal femoral extension osteotomy, bilateral hamstring lengthening and bilateral subtalar and medial column fusion of the feet. Post-operatively, she could walk upright with significant improvement in the gait pattern.

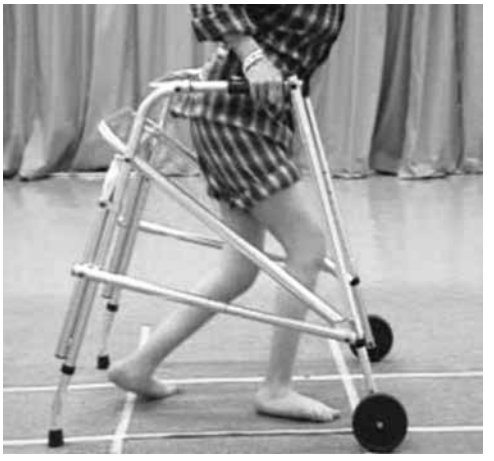

Fig.1a. A 15 years old girl with crouch knee gait before surgery.

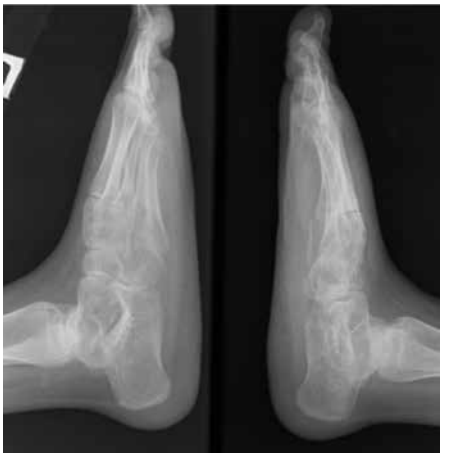

Fig.1b. X-rays of both feet showing loss of foot arches and rocker bottom deformities before surgery.

Fig.2a. After single-event multilevel surgeries, the patient could walk more upright with straight knees.

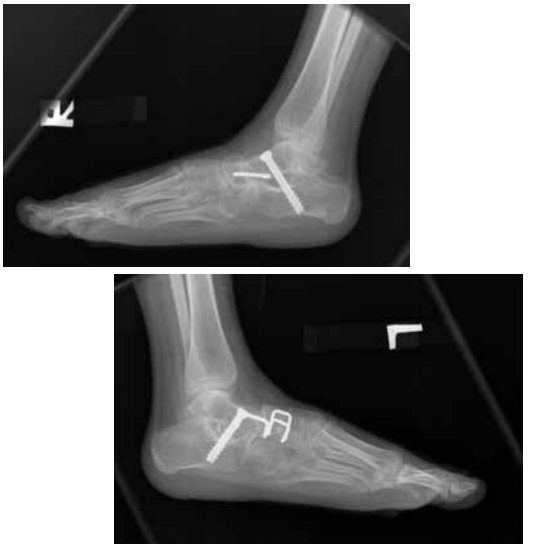

Fig.2b. Subtalar joint fusion and medial column fusion of both feet

Conclusion

Orthopaedic surgery can help to correct some of the abnormalities e.g. muscle contracture and lever-arm dysfunction for patients with CP and thereby help to improve their mobility and daily activities. However, the treating surgeons should be aware of the limitations of the patients and avoid setting unreachable goals. With the advances in neuromuscular research, the understanding and management of CP have improved tremendously over the past few decades. The use of modern assessment tools such as gait analysis can help to evaluate the patients more objectively before surgery and hopefully improve the ultimate treatment outcome.

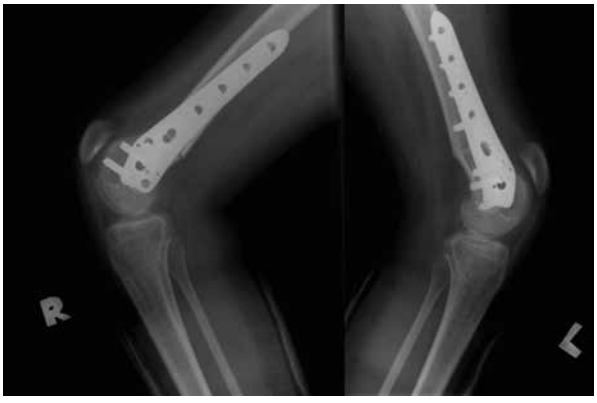

Fig.2c. Bilateral extension osteotomies of the distal femurs to correct the knee flexion contractures.

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BRAINCHILD
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Orthotic Management for Children with Cerebral Palsy

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In 2001, the International Classification of Functioning, Disability and Health (ICF) published by the World Health Organization (WHO) concluded disability in three dimensions, namely, impairments, activity limitations and participation restrictions. By definition, impairment in cerebral palsy (CP) describes a group of permanent disorders of development of movement and posture caused by damage to immature brain, resulting in activity limitation[1].

A multidisciplinary assessment and intervention of the problems resulting from CP is at the core of clinical practice in CP. In collaboration with other medical, surgical and therapeutic treatments, orthotic intervention is often considered as one of the physical management measures for children with CP. Orthoses are designed with two primary aims: assist the functions and improve the biomechanical structure of children with CP[2]. Similar objectives were also identified by the consensus conference convened by the International Society of Prosthetics and Orthotics (ISPO) in 1995, including the following: to correct and/or prevent deformity, to provide a base of support, to facilitate training in skills and to improve the dynamic efficiency of gait[3].

Subtalar Joint and Mid Tarsal Joint

Assessment of Subtalar joint (STJ), also known as the talocalcaneal joint, and mid tarsal joint (MTJ) is particularly important in the prescription of lower limb orthoses. However, there are very few studies which focus on how the orthosis controlled the STJ and MTJ. STJ and MTJ are important joints that connect forefoot and hindfoot to control the foot supination and pronation. The position of STJ also affects the locking mechanism in MTJ[4]. With a normal foot, STJ and MTJ functions change constantly with different points of gait cycle, between stabilized and mobilized structure. Pronation of foot creates a flexible foot as a base of support to accommodate uneven terrain. Foot becomes rigid in supinated position to transmit energy for propulsion. Identification of abnormal STJ position in open kinetic chain and the compensations that occur in close kinetic chain is essential to determine what interventions to make to improve foot and ankle position and the lower limb function.

Vertical heel is selected as the best compromise between eversion and inversion which clinically approximates the STJ neutral. Forefoot is then examined once the hindfoot position has been determined[5,6]. While maintaining STJ in neutral position, the forefoot is considered neutral when the transverse plane of metatarsal heads is horizontal to the line perpendicular to the vertical angle of hindfoot. In children with CP, the STJ and MTJ often fail in their functions due to the deviation in structural alignment of foot and ankle and

muscle imbalance. However, the foot has the ability to compensate these structural deformities and the compensation often occurs through the motion of STJ and MTJ[7]. In open kinetic chain, when STJ is kept in neutral and forefoot is structurally in varus position in relation to hindfoot position, abnormal pronation of foot in close kinetic chain will result as an abnormal compensation (fig.1). On the contrary, the forefoot structurally in valgus position may cause abnormal supination of foot in close kinetic chain.

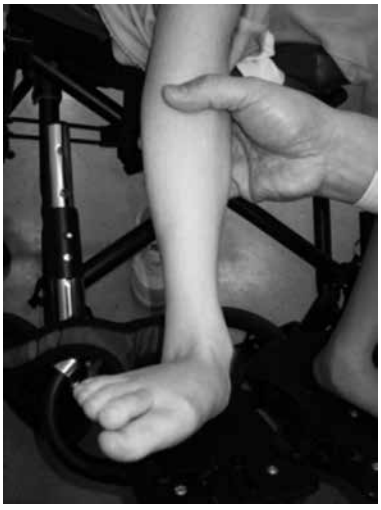

Figure 1. Typical type of pronation deformity

It is, therefore, important to brace the hindfoot in vertical position and post the forefoot, if the abnormal forefoot position cannot be manually corrected. Orthoses with hindfoot control are able to assist the muscle in controlling inversion/eversion and prevent any compensatory deformity.

Gait Deficits

About two thirds of children with CP are able to walk either with or without assistance. Perry describes the three rockers model in sagittal plane of normal gait[8]. The first rocker involves ankle plantarflexion during loading response. The second rocker involves ankle dorsiflexion for tibial advancement during forward progression in mid stance. The third rocker involves ankle plantarflexion during terminal stance to pre-swing for forward propulsion. Owen[9] suggests that the three rockers model is inadequate to describe the event of gait cycle. Therefore a four rockers model (fig. 2) which separate the third rocker into 2 rockers is proposed. The third rocker involves dorsiflexion of metatarsal-phalangeal joint (MTPJ) during terminal stance while the ankle is virtually locked in dorsiflexion. The MTPJ continues to dorsiflex in the fourth rocker and the ankle starts to plantarflex during pre-swing. The rigidity of the ankle in terminal stance is essential for heel rise and maximum knee and hip extension during terminal stance. A normal gait should have the ability to achieve all four rockers effectively.

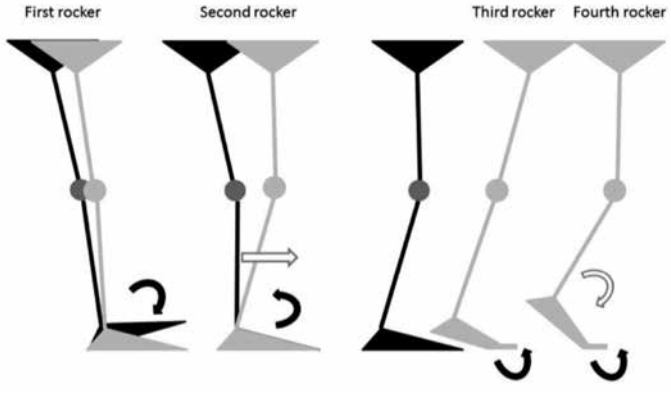

Figure 2. Four rockers model

Only the events of stance phase are involved in the rocker model. The prerequisites of an efficient gait have been described by Gage[10], regarding both stance and swing phases. Stability of the supporting leg is required during stance phase. Sufficient foot clearance from ground during swing phase and appropriate prepositioning of the limb at terminal swing should also be achieved by adequate ankle dorsiflexion. Sufficient step length should be achieved by adequate hip extension of the stance limb and smooth advancement of swinging limb. Energy is conserved without excessive sway of the center of mass of the body. Children with CP may not be able to perform all the rockers and achieve an efficient gait, due to joint contracture or deformity and abnormal muscle tone. Therefore, one of the goals of orthotic intervention is to increase the ambulation efficiency of children with CP by restoring these prerequisites or required rockers for walking.

It is essential to analyze the gait pattern of children with CP when prescribing orthotic intervention. Different children with CP have different gait patterns. Common pathological sagittal gait patterns have been classified according to their characteristics by a number of authors. Two classifications are widely used. One is the 4 gait patterns identified by Winters et al.[11] in children and young adults with spastic hemiplegia (fig.3). There is increasing distal to proximal joint involvement from group 1 to group 4. In hemiplegia, true equinus is usually the basis of these common patterns as there is more distal involvement. In group 1 hemiplegic gait, drop foot is significantly shown in swing phase, with adequate range of ankle dorsiflexion during stance. In group 2, patients show persisted equinus throughout the gait cycle and full knee extension or hyperextension in the stance phase. In group 3, patients also show equinus throughout the gait cycle and had limited knee flexion during swing when compared with group 2. In group 4, more proximal joints are involved especially limited total flexion-extension range of knee joint and hip joint.

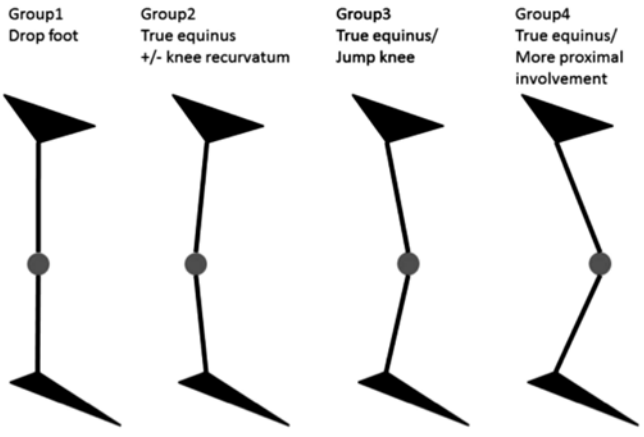

Figure 3. Classification of common gait pattern in spastic hemiplegia by Winters et al.[11]

The other one is described by Sutherland and Davids[12] which classifies the gait characteristics of spastic diplegia into 4 groups based on the knee motions, namely, jump knee, crouch knee, stiff knee and recurvatum knee. Rodda and Graham[13] also classified the gait pattern in 4 groups (fig. 4) with consideration of other anatomical position, i.e. ankle

joint and hip joint, and create algorithms for physical management. The integrity of the plantarflexion-knee extension couple during stance, which is an important biomechanical issue in ankle-foot and knee relationship in order to maintain the ground reaction force (GRF) directed just anterior to the knee joint during stance, should always be considered in the prescription of orthotic intervention. Unlike Sutherland and Davids, recurvatum knee is not included in Rodda's[13] classification as it is often the result of intervention. True equinus, jump knee, apparent equinus and crouch gait are the common gait pattern of spastic diplegia proposed by Rodda et al.[13] In diplegia and quadriplegia, more proximal involvement is seen and therefore apparent equinus and crouch gait are common.

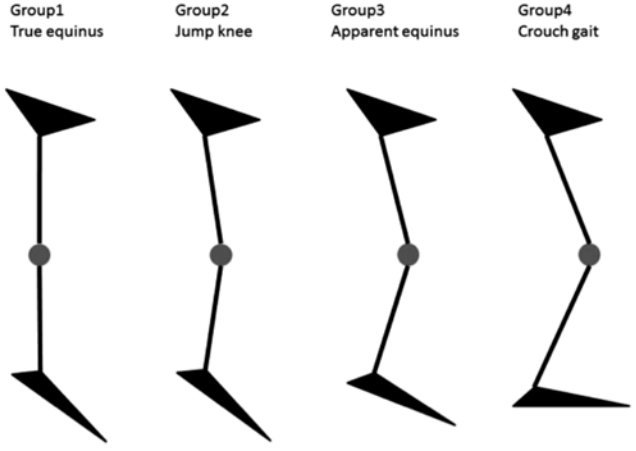

Figure 4. Classification of common gait pattern in spastic diplegia by Rodda et al[13].

Orthotic Prescription for Children

Based on the previous observations, children with spastic CP commonly walk with equinus. First rocker cannot be observed in their gait as stance always starts with toe or foot flat. If there is plantarflexor contracture, second and third rockers are also affected due to the insufficient length and range of gastrocnemius. The vector of GRF passes in front of the knee joint and causes excessive knee extension and hip flexion moment if the initial contact starts with toe during stance. Orthotic interventions that prevent the ankle from plantarflexion, such as rigid AFO (fig.5) or hinged AFO (fig.6) are, therefore, preferred to restore the first rocker and to eliminate the excessive moment that causes knee hyperextension. A recent ISPO consensus conference[14] in 2009 also made several recommendations and conclusion on the orthotic intervention in CP. Evidences from gait laboratory studies show that different design of ankle-foot orthosis (AFO) can prevent equinus during walking, thus improving ankle kinematics, gait efficiency and temporal-spatial parameter, i.e. velocity, cadence, step length, stride length, single and double support, for ambulant children with hemiplegic and diplegic CP. The indirect effects of AFO on the kinetics and kinematics of the knee joint and hip joint have been reported by a number of studies. Better foot clearance and prepositioning of foot in terminal swing have also been reported in different studies[15]. For children with fixed equinus deformity or more proximal joint involvement, the ankle may be kept in plantarflexed position for accommodation and prevention for limiting the maximum knee

extension. In such situations, the shank-to-vertical alignment of using AFO and footwear should be considered[16] in order to achieve optimal lower limb functions.

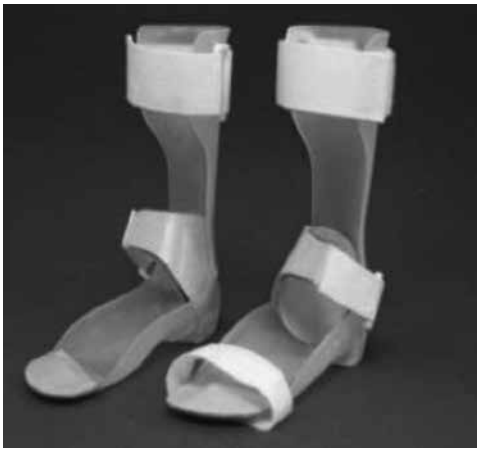

Figure 5. Rigid AFO

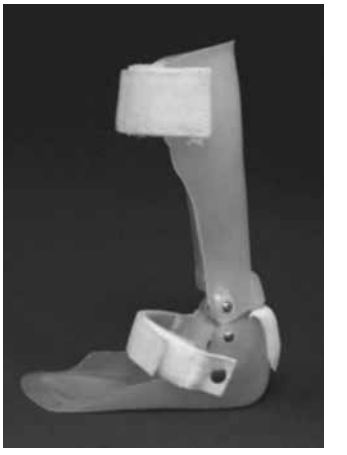

Figure 6. Hinged AFO

For children with more proximal spasticity involvement, the knee joint and hip joint may flex excessively during stance. This causes the GRF passes posterior to the knee joint and therefore excessive knee flexion moment is resulted. AFO such as rigid AFO or ground reaction AFO (fig.7) that prevents ankle dorsiflexion and knee flexion should be prescribed to shift the GRF from posterior to anterior in relation to the knee joint. Contrarily, hinged AFO that promotes ankle dorsiflexion is not suggested for children with crouching gait. In most circumstances, the gait pattern of children changes with age and as a result of intervention[13]. One common change of gait pattern in spastic diplegia or quadriplegia is from toe gait to crouch gait[17], from equinus to ankle dorsiflexion, with the progression of hip and knee flexion due to the biomechanical causes through the involved joints. This change is particularly observed in children primarily with jumping gait, in which the hip and knee cannot be fully extended due to spasticity.

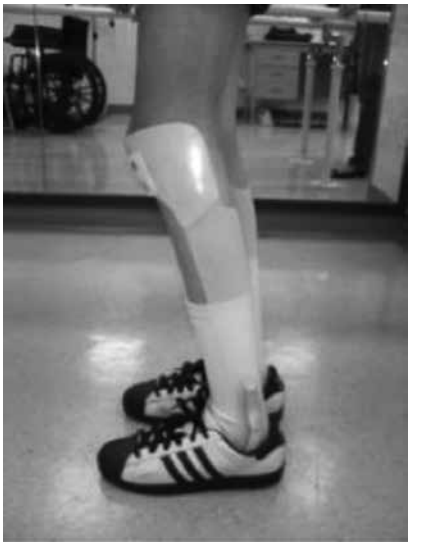

Figure 7. Ground reaction AFO

In the studies by Owen16, tuning of AFO is suggested to optimize the relationship of GRF to the knee and hip joint by fine adjustment of the angle of tibial inclination, approximately 10°-12°. The best stability is achieved with this inclination during mid-stance by using wedge under the AFO or adjustment of heel height of footwear, regardless of the angle of ankle kept in the AFO. In normal gait, the optimal GRF should be directed anterior to the knee and posterior to the hip during terminal stance. For children with excessive knee and hip flexion, which is seen in crouch gait, jumping gait or apparent equinus, this would be difficult to occur. In this case, footwear modification is suggested to improve the terminal stance kinetics. A stiff sole with point loading rocker is suggested to delay the second and

third rocker in order to achieve better alignment of GRF vector, thus improving the knee and hip kinetics[18].

Different studies reported reduction of ankle power generation and absorption with the use of AFOs that restrict ankle motion, especially the rigid AFO. Posterior leaf-spring AFO allows certain degree of ankle dorsiflexion for tibial advancement during second rocker but have no improvement on power generation during third rocker and fourth rocker. However, the restriction of ankle movement is still necessary for optimizing other parameter of gait. Carbon fiber spring AFO (fig.8) is therefore designed to promote ankle dorsiflexion for energy storage during second rocker and ankle plantarflexion for energy release during fourth rocker. Without sacrificing the abnormal ankle kinematics, Carbon fiber spring AFO is able to maintain more normal ankle kinetics.

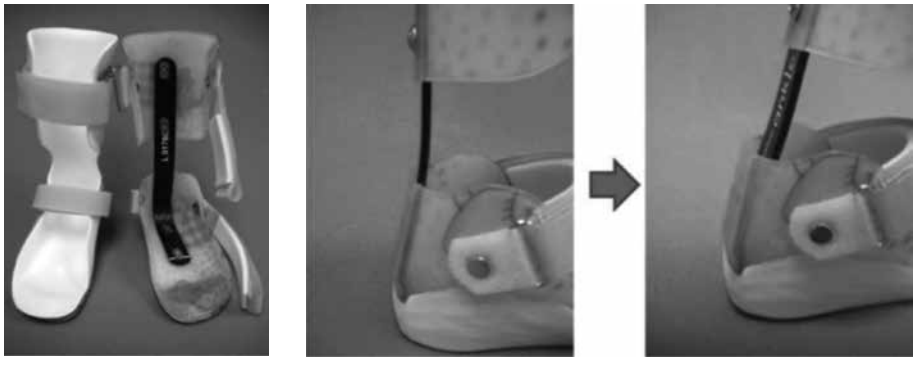

Figure 8. Carbon fiber spring AFO. Energy is stored during deformation of carbon fiber.

Apparent dorsiflexion is also commonly observed in children with CP. The prolonged dorsiflexion moment may cause the foot to be buckled15 (fig.9) which eventually causes the hindfoot eversion or inversion deformity and mid-foot collapse if the foot is insufficient to maintain the rigid lever. This is usually the problem of malalignment of the STJ and MTJ and insufficient length of gastrocnemius. In this case, supramalleolar orthosis (SMO) (fig.10) that can support STJ and MTJ or a rigid AFO that accommodate the length of gastrocnemius and prevent either dorsiflexion or plantarflexion would be appropriate to prevent deformity at hindfoot and mid foot.

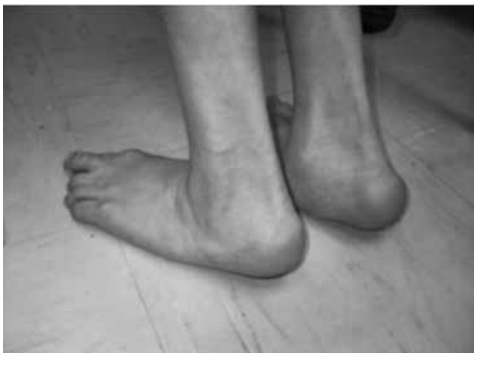

Figure 9. Apparent dorsiflexion

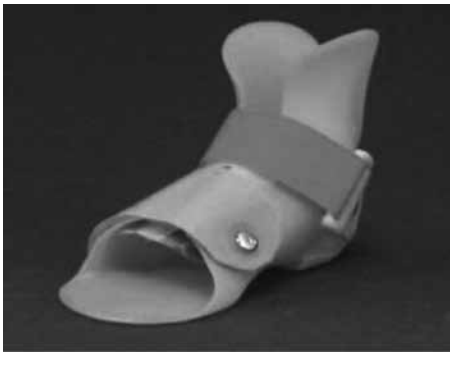

Figure 10. Supramalleolar orthosis (SMO)

Conclusion

CP is associated with a heterogeneous level of disability. Although many studies have been conducted to demonstrate the effect of orthotic intervention for children with CP, the benefits are still controversial due to inadequate reporting and lack of transparency on the types of patients and the design of orthoses[14]. Higher level of study is essential to find out how the design of the orthoses improves the activity level of children with CP. As mentioned at the beginning, the care provided for children with CP needs to be multidisciplinary. Orthotic intervention should be effectively prescribed in collaboration with different disciplines and eventually achieve the common goal among the children, their family and health care providers.

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Physiotherapy Management for Children with Cerebral Palsy

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Introduction and Overview:

Children with Cerebral Palsy (CP) often encounter different problems including physical dysfunction, disturbances of movement, sensory motor and growth problems. Associated complications include spasticity and contractures, feeding difficulties, vomiting, constipation and respiratory problems[1]. Some severe cases may also have problems affecting sleep.

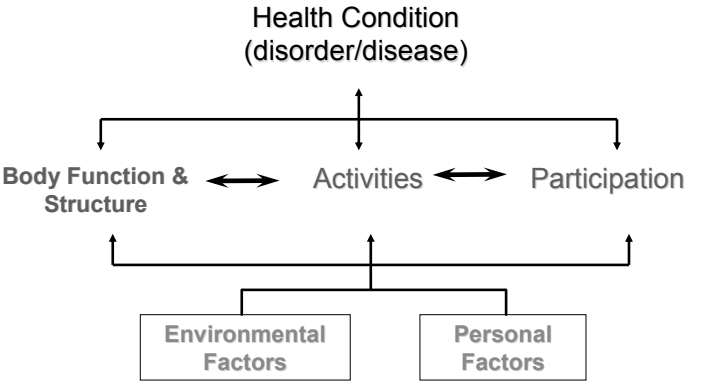
The goal of management of children with cerebral palsy is to improve functional capability, sustain health in term of locomotion, cognitive development, social interaction and independence. Intensive therapy and early intervention are found to lead to best outcomes for children with CP[2].

Spasticity is a major challenge for patients with neurological problems. Children with CP always encounter different degree of movement disorder in the presence of spasticity. Malalignment of body structure as a result of long term effect of increased muscle tone will further cause associated problems such as limited locomotion. Gastrointestinal (GI) problems including difficulties in feeding, vomiting and constipation are common in patients with spastic CP. Physiotherapy management aims to improve the body alignment, which not only facilitates mobility, but also promotes gastrointestinal function and ultimately better health of patients with CP.

Spasticity and Functions

More than 80% of children with cerebral palsy belong to the spastic type[3]. Spasticity prevents or limits the development of motor functions. Management of spasticity for children with CP aims at improving the biomechanical alignment of the body and in turn improves functions. According to the International Classification of Functioning, Disability and Health (ICF)[4], a treatment goal should be set at improving the Activity and Participation levels of patients. Moreover, the Gross Motor Function Classification System (GMFCS)[5] helps to improve professional communication when providing different form of management to the children with different functional levels. Patients with GMFCS level I to III are the groups with better mobility function. Spasticity management for these groups of patients may be targeted to improve the walking and mobility. Whereas, for GMFCS level IV and V, limited mobility functions from more severe impairment require treatment that improves body alignment by providing better positioning in seating. For these groups of CP, more GI problems were reported[6]. Therefore, intervention to reduce GI problems is essential in promoting good health and better quality of life.

International Classification of Functioning, Disability and Health (ICF)(2001)



Role of Physiotherapy in Spasticity Management

There are two components of hypertonia - neurogenic and biomechanical[7]. The neurogenic component refers to the overactive muscle contraction while the biomechanical component refers to the stiffening and shortening of the muscle and soft tissue. If spasticity is left untreated, a vicious cycle is triggered off by the unopposed contraction of spastic and dystonic muscle groups, leading to an abnormal limb posture. This results in soft tissue shortening and biomechanical changes in the contracted muscles. This further prevents muscle lengthening and perpetuates tonicity[8]. During the first assessment, therapists would confirm whether the spasticity is hindering functions. The pattern of spasticity is then analyzed to see if it is generalized, focal or multi-focal.

Massage, myofascial release and acupressure are manual techniques that can improve tissue biomechanics, through increasing flexibility of soft tissue and reducing tightness. Passive stretching programs, splintage and positioning are all essential in preventing deterioration of body alignment. Facilitation of active control of the limbs and the strength of trunk and limb muscles are important in promoting functional movement of children with CP.

If physical treatment alone is not sufficient to overcome the increased muscular tone or its mechanical consequences, medical treatment and other interventions should be considered. Intramuscular botulinum toxin injection is a treatment of choice for focal spasticity. Its effect lasts for 2 to 3 months during which there is better motor control and facilitates intensive therapy following botulinum injection. Functional gain can be observed even after the effect wears off [9]. Casting to lower limbs after gastro-soleus injection is effective in improving the range of motion of the ankles[10].

For those with spastic diplegia with functioning at GMFCS level I to III, selective dorsal rhizotomy (SDR) may be one of the options to manage spasticity. Physiotherapists

play a major role in assessing the mobility of patients through gait analysis and physical examination, which also help to identified suitable candidates for this definitive procedure of spasticity management. Intensive training program after SDR is one of the determining factors affecting outcomes of children with SDR.

Gait analysis before SDR

Intensive Physiotherapy Program after SDR (8-weeks program)

Early Spasticity Management to Promote Functions

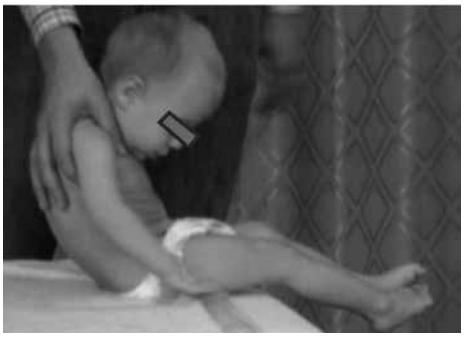
Most physical treatment targeted on improving the standing and walking functions. As such, the important role of crawling might be ignored. Crawling is essential for young children to explore the environment and to learn from it. Crawling builds up both core and girdle muscles[11] to prepare better development of gross motor function. Children need good power and control in the shoulder girdle so that they can move between four point kneeling and sitting position, to rotate body on sitting posture with one arm support and to reach for toys. The core muscles and the pelvic control are important in preparing for standing and walking. Therefore, treatment to improve the upper limbs weight bearing and hip dissociation (isolated movement of hip), such as through Botulinum Toxin injection, may be the first goal to be addressed. For this, examination of upper limb muscles such as the biceps, brachialis, flexor carpi ulnaris, pronator teres and quadratus for elbow and wrist extension in weight bearing during crawling, and examination of lower limb muscles such as hip adductors and iliacus for lower limbs movement during crawling, need to be carried out.

Normal baby using arm for weight bearing and reaching toys

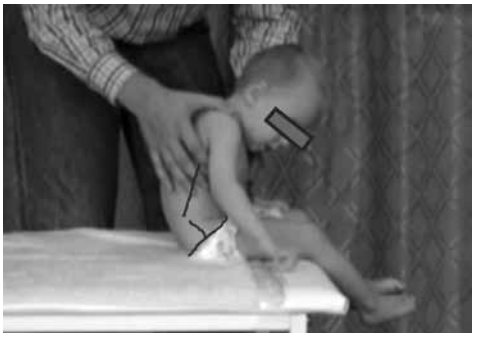
Spastic upper limb limiting crawling function

Sitting is also an area we need to emphasis for those with spastic diplegia. Ability to sit stably and play with toys facilitates learning. Proper alignment in sitting for babies,

especially during feeding, helps to prevent spinal deformity. Spasticity of lower limbs muscles - hamstrings, hip adductors and iliopsoas hampers sitting posture. These children either sit with a round back secondary to the pull from hamstrings muscle or they compensate with "W' sitting posture (kneel sit) so as to alleviate the pull from the spastic muscles. Botulinum toxin to proximal muscles of the lower limbs such as hamstrings, hip adductors or iliacus will help to adjust the spinal alignment while sitting. With proper sitting posture, trunk muscles could be effectively trained.



Spasticity over lower limbs affect sitting



Sitting with posterior pelvic tilt and round back

Associated Problems

Gastrointestinal Problem

Study showed that 92% of children with cerebral palsy have clinically significant gastrointestinal symptoms. Swallowing disorders were present in 60% of patients, regurgitation and/or vomiting in 32%, abdominal pain in 32%, episodes of chronic pulmonary aspiration in 41% and chronic constipation in 74%[12]. The clinical consequences are malnutrition, failure to thrive with poor muscle development, and repeated aspiration causing respiratory problems[13]. Therefore, intervention to improve the GI problem is essential to promote the health condition of children with CP and hence better functions could be achieved.

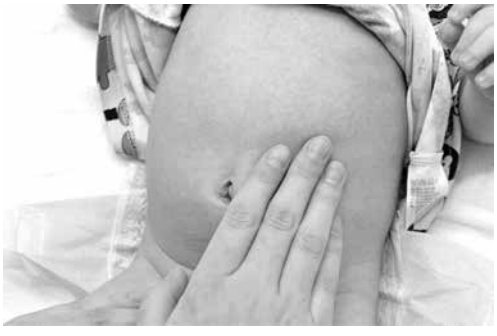
Feeding Problem

Impaired oral-motor functions can cause hypoxemia, temporomandibular joint contractures, vomiting and aspiration pneumonia, poor nutrition, failure to thrive, drooling and communication difficulties[1]. Therefore, it is important to improve oral motor function and feeding. Moreover, poor postural control of head is also a contributing factor for impaired feeding functions. Proper body position, with neck slightly flexed, promotes normal head and oral motor activity during feeding and is essential for proper breathing patterns. Proper coordination of oral motor musculature, swallowing and breathing is essential for safe feeding[13]. Patients with exaggerated neck extension, due to spasticity or tightness of posterior neck muscle, inhibit muscular movements of swallowing might increase the risk of aspiration[14]. Myofascial technique to improve the cervical alignment and motor facilitation training could be the primary treatment for the patient with poor oral-motor functions.

Myofascial technique to posterior neck to promote cervical alignment

26% of children with CP encountered problem with aspiration during feeding[15]. This can be secondary to muscle weakness, poor coordination or dystonia of the oropharyngeal motor control. Inadequate function of cheek and lip musculature may prevent the formation of an adequate lip seal which inhibit distal propulsion of food[16, 17]. Spasticity or tightness over the facial or cheek muscle is noted in clinical practice. Myofascial manoeuvre or message technique over the cheek and oropharyngeal region can improve the oral motor function and facilitate swallowing action.

Gastro-oesophageal Reflux (GOR)



Gastro-oesophageal reflux (GOR) appears to be more common, persistent and severe in children with CP. This may be partly caused by spasticity of abdominal muscles that increased intra-abdominal pressure, but it is likely that uncoordinated oesophageal and sphincter muscle activity also plays a part[18]. Physiotherapy technique with massage to abdominal region can decrease frequency of vomiting and improve milk intake and thus promoting weight gain[19, 20].

Constipation

Constipation is a common problem of children with CP. The limited motor function and the spasticity over abdominal and trunk muscles are the major contributing factors. Massage to abdomen with myofascial technique had been used to relieve the symptom of children with CP. As reported by carers, massage technique is superior to other intervention in alleviating constipation, and supported by studies on massage effect[21, 22, 23, 24]. Regular exercise to improve the mobility of children with CP is also important to reduce constipation and promote bowel movement.

Conclusions:

The goal of rehabilitation for children with CP is to promote the quality of life and improve functioning for better participation. Spasticity which results in alignment problems and myofascial tightness affect different functions including the GI function. Physiotherapy techniques on myofascial release could be one of the methods in relieving the symptoms. Causes and consequences of impairment of children with CP interact to affect outcome. For this, the rehabilitation teams need to view the patient as a whole, through which better function could be achieved for all children with CP.

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Occupational Therapy for Managing Children with Cerebral Palsy

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Children with cerebral palsy suffer not just from developmental motor disorders that evolve with age, but also from disturbances in sensory and perceptual functions which lead to dysfunction in the daily occupations of childhood. Children with CP may have visual and auditory reception and processing deficits[1]. Visual impairment such as blindness, uncoordinated eye movements and eye muscle weakness affect as many as 50 % of children with CP. Children with severe involvement are more likely to have visual impairment[2]. This can be accounted by deficits in oculomotor control or brain processing deficits towards visual information. Auditory reception and processing deficits also impact about 25 % of individuals with CP[3]. In addition, children with CP may have difficulty in processing tactile and proprioceptive information, such as grip force activities of daily living.

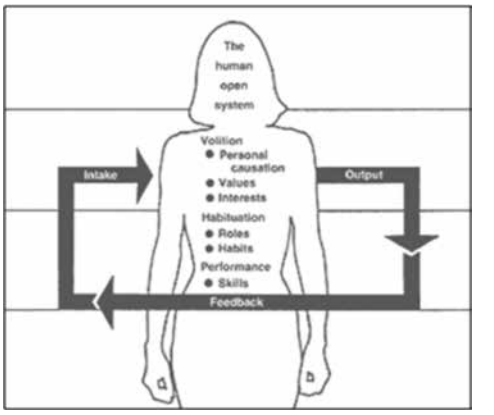
Whatever the age of children with CP, occupational therapists (OT) can facilitate their adaptation throughout the life span in order to function and participate in their everyday environment.

The International Classification of Function (ICF), The International Classification of Function for Children & Youth (ICF-CY) and the Model of Human Occupation (MOHO) are adopted by OTs in establishing rehabilitation plans for children and individuals with CP. Child health status, developmental characteristics, manifestations of disabilities, and involvement in everyday activities can be examined within the unique context of a child's social and physical environment. ICF-CY provides a rich and holistic understanding of functioning that is particularly valuable in the setting of childhood disabilities and rehabilitation, and also systematically guides planning for both individual intervention as well as for large programmatic decisions[4]. ICF is important in CP because of its expanded way of thinking about functional well-being through family-centred service, and through consideration of the factors that mediate between people's "capacity" and "performance", thereby facilitating the individual's full participation in all aspects of life[5].

Students with cerebral palsy constitute the main population in Hong Kong's special schools for children with physical impairment. Contextual factors in special schools favour

the skill-building, routine setting and long term coaching of the students by the occupational therapists through the application of the MOHO[6, 7]. In MOHO, humans are conceptualized as being constituted from three interrelated components: volition, habituation, and performance capacity. Volition refers to the motivation for occupation, habituation refers to the process by which occupation is organized into patterns or routines, and performance capacity refers to the physical and mental abilities that underlie skilled occupational performance.

Among the most challenging aspects in developing independence and competencies in children with CP are psychological issues, described under personal factors of the ICF. It is also the key components of the MOHO. Through reference to the rationales of ICF and MOHO, OTs work with other disciplines to treat, develop and nurture competence and self-directed participation in individuals with cerebral palsy through critical stages of their lives



In Hong Kong, OT services are delivered to these children through the Hong Kong Department of Health Child Assessment Service, Hospital Authority Departments, special schools and home-based and private practice. The goal is to help them achieve the maximum level of independence and to develop their full potential in practical life skills.

OT Assessment

Early identification and intervention by OT may prevent deformity, minimize the use of compensatory and dysfunctional movements, which could lead to secondary impairments and decreased functional abilities for children with CP. Assessment information, including parental concerns and priorities are used to formulate treatment goals. Examples include increasing the child's ability in writing activity and teaching family members adaptive techniques so that they can bathe or feed a child with greater ease. Goals for the adolescents might address accessing public transportation and pre-vocational skills. Recently, due to the education policy of inclusive education in Hong Kong, there is an increasing demand on occupational therapy assessment for special examination arrangement for candidates with CP in public examinations.

Manual Ability Classification System (MACS)[8] is one of the functional classification systems used for children with CP. It describes how they use their hands to handle objects in daily activities in terms of five levels. The levels are based on the children's self-initiated ability to handle objects and their need for assistance or adaptation to perform daily manual activities, such as eating, dressing, playing, drawing or writing, in the home, school and community settings. In addition, other standardized assessments together with clinical

observation and interview with care takers, are also adopted during occupational therapy sessions in order to identify clients' needs.

OT Intervention

Different frames of reference (Neuro-Developmental Treatment, Sensory Integration, Visual-perception, Biomechanical and Psychosocial) are applied in practice to generate tailor-made rehabilitation plan for individual clients[9, 10].

Current evidence-based interventions include various training modalities, the use of adaptive equipment, splintage, environmental adaptation, functional and goal-directed therapy are presented as follows:

Training

Constraint-induced movement therapy (CIMT) is evidence based on the phenomena of "developmental disregard". CIMT targets the functional use of the child's affected upper extremity through engagement in intensive practice and restricting use of the unaffected, stronger upper extremity. Constraint may be provided in a number of ways such as gloves or splints. Ongoing therapy and constraint programme are to be delivered by child's primary therapist[11-14].

Robotics and computer-based gaming technology are increasingly used to enhance motor and cognitive performance in children with CP, due to their advantages of interactive sensory feedback and adjustable clinical parameters. For instance, therapists can set the motion range required for the game, at just-right challenge level for individuals[15].

Bimanual training is also often used in occupational therapy to encourage body symmetry and train up various forms of bilateral integration in functional tasks and activities [16, 17].

Apart from motor training, **cognitive and visual-perceptual training** may also indicate for children with CP during occupational therapy sessions. These training include attention, memory, logical sequence, visual perception and discrimination of visual, tactile and auditory information.

Children with CP may also need specific training for certain self-care tasks and adaptive skills to improve independence for activities of daily living in school and at home. Specific training and adapted tools may be indicated for all these functional activities. Sometimes, one may consider adaptations and modification for fine motor tools such as scissors, writing utensils. Specific handwriting and curriculum access may also be assessed through education.

Due to the impaired motor and sensory control at oral and pharyngeal parts, feeding children with CP is always a challenge to the parents. They commonly experience excessive drooling and feeding difficulties. The asymmetry in tone and strength of muscles groups, sensory awareness deficit, predominately abnormal reflex as well as deprivation of normal feeding experience may contribute to the underlying factors. OT helps them to improve drooling condition and to acquire safe and efficient oral feeding capability by providing oral motor training, giving advice on food consistency, prescribing optimal seating systems or sitting positions, transferring feeding techniques to care takers and suggesting appropriate feeding utensils.

Application of Splints

Splinting can be used to improve hand function, support optimal movement pattern, prevent joint contracture, improve hygiene, or relieve pain in a specific joint. It should be tailor-made to enable tolerable but prolonged stretches for prevention and correction of contracture deformities. Serial splinting and training, coupled with the use of local injection of Botulinum toxin A might improve hand function[18]. Effective design of dynamic splints may encourage hand function training.

Splinting might be able to reduce undesirable behaviors. For example, children with severe elbow flexion tone may poke his or her own eyes involuntarily, causing eye injury or infection. In this circumstance, elbow gaiter or dynamic long arm brace (which allows certain elbow range but inhibit the most inner elbow flexion range) can help to prevent self-injury. Children with spasticity at thumb adductor, flexor and opponent muscles will present as thumb-in-palm deformity. Thumb spica splint can help the child to grasp or pinch object in a more functional way.

Adapted Seating

Children with CP are commonly at risk for joint contractures, deformities and misalignment due to spasticity. If they are chair-bound and cannot shift their weight independently, there is a higher risk of skin breakdown. By providing children with CP with adapted seating, OT provide opportunities for children with CP to maintain optimal upright posture and bear weight in a variety of positions, and to provide a stable base for facilitating upper limb function and inhibiting abnormal reflexes.

Adaptive Device and Environmental Adaptation

A variety of adaptive devices, equipment and environmental adaptation can assist children with CP to complete self-care, play and educational tasks. These devices serve to maximize independence despite restricted capabilities. OT selects devices that match the child's motor needs while simultaneously considering other factors such as sensory functioning, intellectual capability, psychological and environmental factors[19]. Dressing aids, feeding aids, adapted computer-input devices and handrail may be prescribed for children and adolescents with CP, as are devices and modes for communication access such as Alternative Augmentative Communication measures, to enhance daily life.

For clients with severe disabilities, OTs can give advice concerning community service to optimize both external and internal access. These may include use of ramp, hand rails, ergonomic advice in display so that essential material and facilities can be reached easily, appropriate width of door and corridor, aids for bathing and toileting, pressure relieving system such as mattress, and related sleeping system.

Sometimes through collaboration with engineers, OTs provide advice on home-based environmental control according to the strength of individual client.

Home and School Adaptation

For children who suffered from acquired cerebral insults resulting in physical impairment, OTs play a part to re-integrate into daily lives after discharge from hospitals. Functional training, environmental modification, liaison with school teachers for school activities and homework, are some of the important factors in enabling a smooth transition from hospital to home and school.

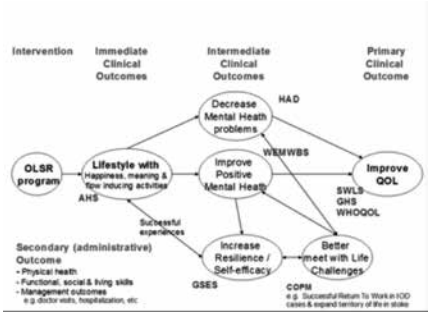
Social and Recreational Participation

Home, work and leisure are the domains of occupational therapy. Children with disabilities are more restricted in their participation compared with their peers. Their leisure activities tend to be limited; they attend fewer social engagements and spend less time in recreation than their typically developing peers[20]. After task analysis, capability-demand matching and modification of specific activities will be supported by OTs to assist children with CP, such their scope of recreation options are maximized. Hippotherapy is one example of such activities that promote social and recreational participation.

Occupational Lifestyle Redesign Programme (OLSRP)

There are some common problems in adolescents with chronic illness that hinder their participation in community after graduation from mainstream school. In order to encourage transition from adolescent to independent adult life[21], OTs implement Occupational Lifestyle Redesign Programme (OLSRP) which is found to be effective in helping clients reaching their own goal. OLSRP is a process that requires active and conscious effort for exploring, experimenting, habituating, internalizing old and/or new occupations. This includes self-care,

home maintenance, work, leisure, social and spiritual activities. Patients have to prioritize and organize them into a new occupational lifestyle in which physical and mental health can be maintained, spirit be nurtured, personal growth be facilitated, meaning and happiness be fostered.



The OT interventions for children with CP are common amongst different sectors with services geared towards different stages of life. These services carry their own individual characteristics are summarized in the appendix for reference. In summary, Occupational Therapists' practices, in no exception, are based on the vision that "All our clients shall lead the meaningful life of their choice".

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Useful Websites:

1. Health & Wellness Fact Sheets ~ Addressing Sensory Integration Across the Lifespan Through Occupational Therapy, American Occupational Therapy Association.
   http://www.aota.org/en/About-Occupational-Therapy/Professionals/HW.aspx
2. Occupational Therapy service in Gillette Children's Specialty Healthcare, USA
   http://www.gillettechildrens.org/conditions-and-care/occupational-therapy/
3. Paediatric occupational therapy service of Australian Government, Department of Social Services
4. Evidence Brief Series: Cerebral Palsy, American Occupational Therapy Association
   http://www.aota.org/practice/children-youth/evidence-based/eb/cerebralpalsy.aspx
5. The Royal Children's Hospital Melbourne
   http://www.rch.org.au/clinicalguide/guideline index/Cerebral Palsy/
6. BMJ Best Medical Practice:
   http://bestpractice.bmj.com/best-practice/monograph/674/treatment/step-by-step.html
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   http://www.waikatodhb.health.nz/assets/for-health-professionals/
8. New-spasticity-guideline-promotes-prompt-access-occupational-therapists, British Association of Occupational Therapists and College of Occupational Therapist
   http://www.cot.co.uk/news/

Appendix : **Focus of Occupational Therapy Services for CCP in Different Developmental Stages**

Types of Services	Characteristic of the developmental stages	Age range	Focus of services
Child Assessment Service	Child Assessment Service includes a multi-disciplinary team for providing comprehensive assessment of the client. Diagnosis, education and rehabilitation plan are formulated with team consensus. Setting up of training goals, prescription of rehabilitation equipment and referral to services & training will be made.	0-12 years old	• Conduct assessment on OT related areas (neuromotor status, sensory & perceptual functions, fine motor skills and functional level in self care, play, schoolwork) in relation to different transition points. • Provide support on proper positioning, mounting of test materials and suggesting indication mode in the team assessment process, so as to elicit his/her best performance. • Provide assessment on physical access of assistive technology and mounting of device in Augmentative and Alternative Communication (AAC)
Preschool service	CCP at such a young age has to receive training and education as early as possible to maximize their developmental potentials, which facilitate their integration into the primary education in ordinary or special schools. Through well planned, goal directed playful learning activities in individual and group training sessions or whole day programs, OTs adopt evidence-based training strategies to facilitate the child development particularly on fine motor, pre-writing and writing skills, postural control, self-care, cognitive and social emotional development. Intensive support to CCP families and care-givers to enable them to accept, train and care for their children is strongly emphasized. OTs equip parents and caregivers with knowledge and skills, understanding their roles in facilitating the overall child development, training and caring of their children so as to promote positive behavioral management and nurturing positive parent-child relationship.	Birth to 6 year old for Early Education Training Centers (EETC) Birth to 6 year old for Early Education Training Centers (EETC) 2-6 years old for Special Child Care Centers (SCCC)	According to the severity of disabilities, the needs of CCP and parents' concerns, they will be referred to EETC or SCCC and receive OT. Scopes of services included such as : • Fine motor training, e.g. coordination and hand dexterity • Basic self-care training on oral motor control, feeding, drinking, toileting; dressing and grooming • **Pre-writing skills and handwriting skills training**, visual perceptual training, ocular motor control • Play skills for cognitive and social development • Sensory processing intervention to improve sensory modulation, postural control, praxis and organization • Design and prescribe adaptive aids and devices to enhance CCP's learning and independence in center and at home • **Enhance transition to a new school setting** such as mainstream primary school with preparatory programs • Education and training to parents or caregivers to enhance continuing children' training and proper caring at home • Support and consultation to pre-school teachers and other staff in centers or even in mainstream kindergartens

Types of Services	Characteristic of the developmental stages	Age range	Focus of services
Special school Service	OT provide an integrated, holistic and whole-day management program to improve the student's performance and independence in tasks and activities important for successful school functioning and social integration in three domains (ADL, study and leisure). Nurturing and developing our students' will, attitude and abilities for self-determination and self-reliance from a very young age and on a daily-basis is one of the exclusive feature of the integrated program under the principles of Conductive Education. As one of the core trans-disciplinary team, OT uses an intensive, integrative, and in-context approach that based on the contemporary perspective on disability and evidence-based approach for neuro-rehabilitation. Adopt both top-down and bottom-up learning approaches that carry the characteristics of task-specific, goal-directed and intensive repetitions in real context for enhancing neuroplasticity.		• Create, in collaboration with different professionals, active learning environment and routines that facilitate students' participation in school at home and in community • To assess and treat performance components to handle core problems in various occupational performances • to improve their performance in various environments, and optimize their performance with assistive devices and accommodations • collaborate with parents to support their children's learning and participation • play a critical role in training parents, caregivers and other staff • to develop school-based integrative curriculum in order to facilitate the integration of education and rehabilitation • to plan and to teach collaboratively with the teachers in school lessons to ensure students' transfer and generalization of learning and rehabilitation • facilitate students in preparing for successful transition into appropriate post-secondary education, employment, independent living, and/or further education • ongoing assessment and recommendation for the students who need special examination arrangement (SEA)
Occupational Lifestyle Redesign Programme for Adolescents	Ultimately adolescents with CP can develop a concrete plan of future, including work plan, proper work habit and enhance interpersonal skills and social skills Through practice of the self-initiated "my own action plan" weekly, to improve their sense of success; Through organizing activities, they can practice the team work, all interpersonal skills like management of conflict, emotion, money, etc. Eventually, to cultivate the happiness of achievement, To let them understand there are ample of choices throughout life. OTs will shape and manipulate the ENVIRONMENT for the adolescent to experiment and create another way to practice LIFE	15-25 year old	Mission of the OLSRP: • Develop a platform to link up chronically ill adolescences with the community • Facilitate and redesign ones occupational lifestyle through active participation • Improve self-efficacy and develop future plan with expanded scope and content Scope of services included • Pre-vocational training; • Job matching and placement • Vocational assessment, exploration, counseling and training • Intensive close-group training to encourage active participation of the adolescents

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Intensive Rehabilitation Program in Schools for Children with Physical Disabilities Using an Integrative Approach

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Introduction

SAHK operates 3 special schools for students with physical disabilities in Hong Kong. These schools provide curriculum streams that are specifically designed for students with various intellectual abilities, from moderate grade intellectual disabilities to normal intelligence and from primary to senior secondary schooling. Concurrently, they also provide rehabilitation services including physiotherapy, occupational therapy and speech therapy and one of them offers boarding provision.

By adopting the principles of Conductive Education, our schools put integrative learning approach into rehabilitation practice, rehabilitation programs are delivered in a unique way that is in context with the available evidence on effective rehabilitation approaches for cerebral palsy. In the subsequent sections, philosophy and features of such rehabilitation programs with particular reference to post-intervention management will be discussed.

From Medical to Biopsychosocial Model of Disability: From Restoration of Body Functions to Cultivation of Self-determination

Instead of looking at disability as an impairment of body function and structures and delivering treatment to 'cure' the problems through bottom-up approaches, we embrace the biopsychosocial model of the WHO International Classification of Functioning, Disability and Health (ICF)[1]. ICF posits that biological, psychological (which entails thoughts, emotions and learning), and social (both interpersonal and contextual) factors, all play a significant role in human functioning in the context of disease or illness. Accordingly, addressing biological deficits is necessary but not sufficient for both routine and post-intervention rehabilitation of individuals with disabilities. In a recent systematic review on the effective approaches for cerebral palsy rehabilitation, Novak et al. (2013) concluded that bottom-up approaches that work mainly at the impairment level are not effective strategies[2]. They pointed out that effective approaches in enhancing motor function for children with cerebral palsy are found to be top-down approach based on motor learning theory such as

goal-directed training, constraint induced movement therapy (CIMT), as well as approaches working on the contextual and personal factors, such as context-focused therapy[3-5].

Thus, rather than working only on body structure and function and rectify our students as 'normal', we work on their holistic development and full participation. In our schools, students' all-round needs are addressed with different emphasis and weighting of individual areas at different stages of development or post-intervention recovery. For example, we put more emphasis on body structure and function at primary school age and the sub-acute stage of post-intervention management. However, from senior primary schooling or convalescent post-intervention stage onwards, in addition to the various programs working on body structure and functions, higher weighting will be put on enabling functioning in all possible activities and on maximizing participation by means of a top down learning approach. This actually follows the findings in the paper of Prof. Rosenbaum (2002) on the prognosis of gross motor function in cerebral palsy that there appears to have a plateau in gross motor functions at about 9-10 years old for children with cerebral palsy at the Gross Motor Function Classification System (GMFCS) Level 1 (community walker) and at about 5 years old for those of GMFCS Level 5 (wheelchair dependent)[6].

Rehabilitation for integration and Participation

The ultimate goal of our rehabilitation is to enable students with disabilities to become fully integrated into the community by giving them the best preparation possible from the biological, social and psychological perspectives. A sustainable social and community participation should be achieved through an intensive, in -context, goal-directed, and task-specific learning approach directed towards building a self-reliant and resilient personality.

The 5 Cardinal Features of Intensive and Integrative Rehabilitation

1. Intensive – At EVERY Possible Moment

To maximize brain plasticity and motor learning, "intensity" (i.e. number of repetition) is the key. In addition to various therapy sessions, we adopt the whole school approach of rehabilitation. With provision of carefully scheduled school time table, ample opportunities of body stretching, motor planning, and execution of actions are embedded in activities before, during and after school.

Some typical examples of our round-the-clock intensive programs in a typical school day are tabulated below and it does not include the individual or group rehabilitation sessions in the rehabilitation departments provided for the students:

Time	Approximate Duration	Integrative physical training
Before morning assembly	Approx. 15 mins	• Walking training from school bus to the assembly hall • Attend the gymnasium as fitness club
Daily morning exercise	20 – 25 mins	Specially designed group programs for each students, e.g., community walking group, CIMT, wheelchair mobility groups

Before and at the end of every class lesson (about 8 lessons in a school day)	Approx. 2 mins each × 8 lessons = 16 mins	Greeting teacher while engaging in individualized specific training such as stretching, weight shifting, etc (depending on the student's needs)
In-between lesson exercise	Approx. 5 – 10 min	• Specific exercise for each student
During the class	Approx. 1 hour	• Standing and weight bearing with flexi-stand if indicated • Classroom activities, e.g. for hemiplegics, using the affected hand to clean the whiteboard
Recess time	5 – 10 mins	Exercise program for students, e.g. stepper exercise for weight control
Lunch	Approx. 40 min	Standing and weight bearing training
At the beginning of some lessons especially those lessons that involve movements, e.g Art and Craft lesson	5 mins	Pre-lesson exercise for better coordination before the lesson starts
After school	Approx. 10 mins	Walking from classroom to school bus
Total Time:	Approx. 2.5 - 3 hours	

Daily morning exercise programs for specific needs of students

Daily stretching exercises incorporated into lunch routine and classrooms – standing on a wedge while having lunch to stretch Tendo Achilles

Students stretching wrist and finger flexors and practicing transfer skills in the classroom when greeting teachers at the beginning and the end of each lesson (about 1 min each)

Rehabilitation at lunch time under CIMT – student using the affected hand for self-feeding while constraining the non-affected side

In-between lesson/
recess exercise time for each class

2. Integrative – Across EVERYONE in the School

In the same line to increase intensity of rehabilitation and maximize repetition and therefore effectiveness, a transdisciplinary approach which advocates role release and role expansion across all professional disciplines and downward delegation to supportive staff is adopted. Rehabilitation program is implemented not by therapists alone in their treatment room during therapy sessions, but actually by every member of the school team including teachers, teaching assistants and other disciplines at every possible scenario and venue. For example, in order to train up students with hemiplegia to use their affected hand more with shoulder elevation, teachers and teaching assistants will create natural opportunities for such actions, such as specifically ask the student to clean the whiteboard, hand-in worksheets, handle school bags or other personal belongings with the affected hand, and to raise the affected arm for answering question. Another example is the CIMT program. To motivate the participating students to write or type with affected side while restricting the unaffected side during the 3-week program, teachers are actively involved in making accommodations and adaptations in the worksheet or class activities so that the students can finish the class work without frustration.

Rehabilitation in the lesson – teachers supervise hemiplegic student to use the affected hand to handle learning materials and personal belongings

In the lesson time, a stepper is set to strengthen the lower limb whenever the student participating in the lesson activities on the whiteboard.

In the lesson time, teachers creates opportunities for student to practice transfer skills and walking

With this integrative approach, it allows maximum repetition and therefore effectiveness. The rehabilitation goals of each student are made known to all staff as well as students and parents as these goals are posted on the students' tables or classrooms so that everyone

knows what and how to facilitate the student to achieve the established goals. Regular staff trainings and meetings are required to enable and engage staff of different disciplines in such integrative role.

Transdisciplinary approach – supporting staff involved in walking training in the classroom

Student practicing transfer skill and standing with supporting staff in the toilet as a school routine activity

3. In-context – Practice in Real Context

In the treatment model of rehabilitation, it is often assumed that the patient can automatically transfer the newly learnt skills from the treatment room into the context of daily life. Such assumption may be true for patients with orthopaedic or medical conditions. However, recent evidence revealed that it may not be applicable for those with neurological impairment. Insult to the central nervous system is often complicated with cognitive and perceptual problems besides motor control difficulties. The ability of its sufferers to retain and transfer what has been learned or gained from surgical intervention and generalize it to real life situations is the most challenging part. For our students, learning and practicing functional tasks in authentic environment are not only task-specific and goal-directed, but also motivating and personally satisfying, because the students can relate functionality to the purpose of the movement. In addition, the satisfaction generated from the gains in functional movement together with the activity participation at equal footing with the able-bodied counterpart is in itself both rewarding and motivating.

In contrast to therapy room which is often a simplified, protective and well-controlled environment, the authentic environment is demanding and varying. The routine and post-intervention rehabilitation program in our schools emphasizes practicing and learning in real-life situations such as transfer between wheelchair and seats in the classroom with students moving around as well as in toilet where the space is limited and the floor may be wet. To practice walking, instead of walking within the parallel bars where the students do not see the purpose, it will be much more rewarding in walking between classroom and school bus every day after school, and with gradual

Rehabilitation for integration: Non-verbal student learning to use power wheelchair and notebook to communicate and buy food in the community

introduction of more demanding dual task (e.g., walking while carrying the school bags, etc). For more in-context assessment and training in the classroom, therapists would routinely join in the classroom lessons to teach collaboratively in some compatible subjects like physical education, integrated learning and living skills lessons.

Learning to make use of the context for standing without support in the community while handling money from the shoulder bag

Daily walking training with goal-directed activity – walking out of the classroom to the school bus after school

Physiotherapist in lessons and introducing rehabilitation elements such as trunk control

4. Independenc – Cultivating The will and Ability to be Self-reliant

The fundamental aim of rehabilitation is to be able to do things for oneself which should be started from early childhood or the convalescent post-intervention stage. Rehabilitation program should be designed through ecological assessment, for instance, in preparing for buying lunch in a fast food shop, we will prepare our students in school by designing tasks involving carry a tray with dishes and drinks while walking during our morning program, and then incorporate such tasks in our lunch program for daily practice. Other similar tasks such as picking up dropped things from the floor while holding on walking aids, maintaining standing balance while using a mobile phone on the street, getting money out of pocket while maintaining standing balance, walking with walking aides while carrying shopping bags filled with groceries, will also be designed.

In addition, from very early on or during the sub-acute post-intervention stage, it is very important to address the personal factors in the ICF model. This includes giving plenty of chances for the students to develop skills and experience to tackle and solve their own problems and becoming self-reliant. Despite disability, self-reliant children are able to make choice, to set own goals and to be self-determined. In our rehabilitation program, it is important to work proactively to learn how to face and solve problems, to seek help and to administer self-evaluation and monitor one's own progress.

5. Integration – Rehabilitation for Integration

Community-based Rehabilitation

It is very important for community participation and community mobility to be started at a very early stage. Such training includes walking in all sorts of weather while carrying umbrella or wearing raincoat; negotiating different types of terrain including wet market, slopes, stairs in flyovers and Mass Transit Railway etc. Other skills such as handling falls and choosing protective gear such as knee pads are also important. To maximize effectiveness, walking outside school is embedded in the daily morning exercise programs, some students participate in jogging around the school. For those wheelchair user, learning how to handle kerbs, ramp and slopes is also taught in real context.

Students learning to manage kerb and slope in real context

Learning to walk in wet weather and holding umbrella while maintaining balance

Sustainable Self-management

Developmental disabilities are life-long issues, and therefore preparing our students to self-administer their routine and post-intervention rehabilitation programs is crucial. An important area of our rehabilitation is to move out of the treatment room and introduce the students to use exercise facilities in the park or using the gymnasium in public. Fitness and fun are important for children with neuro-disabilities. Competitive sports such as track and field, swimming, fencing, boccia, table tennis, as well as recreational sports, marathon and hiking are incorporated into our rehabilitation programs.

To empower the sustainability and ownership of rehabilitation, students learn to use public facilities for their own exercise programs

Rowing sport is introduced to the students

Sustainable rehabilitation with a purpose – students participating in the Standard Chartered Marathon

Continuity at home is also essential and home program will be prescribed after paying home visit and the program will be often able to incorporate home life.

Goal-directed home Program– incorporating standing balance training with a meaningful task to the student e.g using the mobile while standing and walking in the community

Encourage daily home exercise by incorporated into daily functions, e.g walking the stairs instead of taking elevators

To facilitate the students to buy-in the ownership of their rehabilitation, the rehabilitation gymnasium will be arranged as fitness club during non-lesson time where students can drop in to do their exercises as their abled-bodied counterparts joining the fitness centre in the community. Token and award system may be used to reinforce progression. For students with the appropriate intellectual ability, they are encouraged to have the initiative and responsibility to book an appointment and make a reservation before they head off to the gymnasium or for rehabilitation sessions.

Students go to the gym at their free time to do exercises with own initiatives

Special Post-intervention Intensive Rehabilitation Program

For students who have undergone recent interventions such as single-stage multi-level soft tissue and orthopedic surgery or Botox injections, the school rehabilitation team will have close communication with the medical practitioners and rehabilitation team from the hospitals to ensure the continuity and consistency in following up the post-intervention protocol. In addition to the regular intensive integrative programs, special arrangement will be made to ensure timely and extra-intensive rehabilitation so as to maximize the surgical outcome during the golden stage of recovery. The main goal is to boost up the intensity of rehabilitation for escalating intervention from the impairment level up to the functional, activity and participation levels. A typical transition accelerated program for those who have undergone surgery or other interventions are outlined as follows:

1. Before Intervention

Close communication with colleagues from hospital with assessment reports and the school rehabilitation team will sit in the multi-disciplinary clinic either in our school premises or in the hospital.

2. Hospitalization Stage

School personnel will visit the student or contact the family through telephone to update the progress and needs of the students.

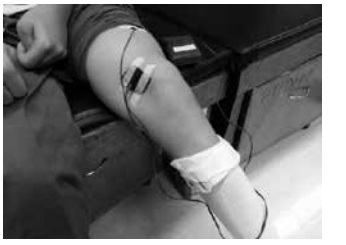
3. Upon Discharge

Arrangement of mobility means such as wheelchair with elevated leg rest will be made in the case of long leg plaster following tendon release. Advice on activities of daily living, in particular, personal self-care activities e.g, bathing and toileting with cast will be prescribed as indicated. Post-operative home exercises and empowerment of parents and domestic maid will also be followed up.

4. Back-to-school

Once the students start to attend school, intensive rehabilitation program will be commenced for the best effect. Depending on the type of intervention, special arrangement for maximizing intensity of program includes:

- increase frequency of intervention, e.g one more session before the school starts or after lunch, or more session on positioning and stretching in the classroom;
- increase the duration of special rehabilitation session, e.g. extend one more session to make a double session;
- re-arrangement of the daily morning exercise program that cater the specific needs of the student;
- special sessions e.g., using treadmill, electrical stimulation for muscle re-education will be arranged as necessary.



The program will focus on gaining soft tissue flexibility by means of splinting, stretching and by low intensity long duration positioning throughout the whole day. Pain and scar management and adhesion prevention will be prescribed using electrotherapy modalities and soft tissue techniques as indicated. Maximum participation in the lessons and other school activities with splints, casts or orthotics will be arranged.

Joint mobilization and strengthening including core stabilization, with open and close kinetic exercises are incorporated as routine activities during the day. Weight bearing, balance and gait training will also be introduced in compliance with the post-intervention protocol and as tolerated. Weight support system will be used in conjunct with treadmill. Video game-based rehabilitation such as using Kinect or Wii-fit is a good adjunct exercise and is very useful and motivating for the students, both at school and at home.

5. Exiting the Transition Program

Such transition program will gradually be phased out once the student can participate in the school activities. Gradual introduction of community-based rehabilitation program and sport activities will then be started as soon as tolerated.

Conclusion

By adopting the biopsychosocial model of disabilities and applying the principles of Conductive Education, our rehabilitation service is delivered in a holistic way that serves as a working model for the ICF model and the contemporary neuro-rehabilitation concepts. By means of detailed scheduling together with the whole school involvement to implement and integrate rehabilitation elements in every possible school activities and class lessons, we have successfully expanded our rehabilitation programs into a whole-day and whole-school approach for maximizing intensity and effectiveness which is crucial particularly in post-intervention management.. By using a top-down motor learning approach that focuses on learning in real context and on goal-directed and meaningful activities, we allow maximum participations in the school, home and community levels from a very early stage of post-intervention recovery. Lastly through cultivating a self-determined and self-reliant personality in our rehabilitation service, we enable our students to have the will and motivation to participate, to integrate and to contribute.

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Developmental Profile of School Aged Children with Spastic Diplegic Cerebral Palsy

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Abstract:

Objectives:

Our study aimed to examine the developmental profile of school aged children with spastic diplegic cerebral palsy of normal range intelligence.

Design:

Cross sectional

Participants:

33 children with diagnosis of spastic diplegic cerebral palsy aged 6-12 years with verbal or performance intelligence in the normal range were drawn from the Child Assessment Service in Hong Kong

Method:

The subjects were assessed by the physical impairment team, which compromised of doctor, clinical psychologist, occupational therapist and physiotherapist. The developmental profile studied included physical functioning, visual perception, handwriting speed, attention, word learning and self-esteem. Assessment tools used included:

Gross Motor - *Gross Motor Function Classification System, Functional Mobility Scale, Gross Motor Function Measure*
Fine Motor - *Bruininks-Oseretsky Test of Motor Proficiency*
Visual Perception - *Test of Visual Perceptual Skills*
Handwriting Speed - *Handwriting test*
Word Learning - *The Hong Kong Test of Specific Learning Difficulties subtests*
Attention - *Three Subtests of the Test of Everyday Attention for Children, ADHD Behavioral Rating (Vanderbilt Assessment Scale to parents)*
Working Memory - *The Digit Span test*
Self esteem - *The Culture Free Self Esteem Inventory*

Results:

According to Gross Motor Function Classification System, 84.8% of the subjects were functioning at Level I and II. Most of the children, 72.7% attained above 90% in Gross Motor Function Measure, lacking only the very advanced activities in the test. 61.3% subjects were below the 16th percentile rank in fine motor composite standard score. More than half of the children had below average visual perceptual performance. Visual closure and visual figure ground were their weakest areas. Results revealed that close to 40-50% of children with spastic diplegia in our study had significant difficulties in their word recognition ability, with 42 % meeting the diagnostic criteria for dyslexia.

Nearly 70 % of children performed in the impaired range of their selective visual attention, close to 50% fell into the impaired range for sustained auditory attention, close to 33 % of the subjects were impaired in their shifting attention. For the Vanderbilt Assessment Scale, 21% of subjects were rated in the clinical range of concern on the inattentiveness subscale. 36% of the subjects performed in the deficit range in working memory. 18% of the children in our study reported low/ very low self esteem

Conclusion/significance:

This study showed that children with spastic diplegia did not only have deficit in gross motor skills. Many of them were also weak in fine motor skills, visual perceptual skills, selective visual attention, sustained auditory attention, word learning skills (reading, dictation) and working memory. This could affect their participation in school and social life as well as the development of self-esteem. A comprehensive and interdisciplinary team approach to rehabilitation and reviewing concerns raised by parents or teachers as the children grow will address their developmental needs effectively.

Background

"Cerebral Palsy is a major cause of childhood physical disability. Cerebral palsy describes a group of disorders of the development of movement and posture, causing activity limitation, that are attributed to non-progressive disturbances that occurred in the developing fetal or infant brain. The motor disorders of CP are often accompanied by disturbances of sensation, cognition, communication, perception, and/or behaviour, and /or seizure disorder"[1]

Literature review on the prevalence and characteristics of children with cerebral palsy showed that other than motor impairment, they also have intellectual impairment[2,3], attention problem[4], visual spatial problem[5,6,7] and learning difficulty[8]. This is also supported by our team's clinical experience.

A study showed spastic diplegic children had poor scores in the performance scales of Wechsler Preschool and Primary School Intelligence Scale (WIPPSI) and in the locomotion, eye-hand coordination and performance scales in Griffiths Mental Development Scales[3]. Children with cerebral palsy had more symptoms of inattention, hyperactivity and slower processing speed[4].

Any one of the above impairments would be a hurdle to a child's development and learning. Very few studies have included all the above areas in one research to give a fuller developmental profile of children with cerebral palsy beyond physical impairment. Furthermore, some of the children may have several problem areas at the same time. This would affect their schooling and participation in multiple areas.

For this study, the target population were children with spastic diplegia. They were chosen among the various types of cerebral palsy because we would like to focus on one type of cerebral palsy to start with for easier comparison. These children were more likely to have close to normal intellectual functioning (a more homogenous population group).

Objectives

To examine the developmental profile of school aged with spastic diplegic cerebral palsy with normal intelligence.

Method

Subjects

This project recruited all children seen at Child Assessment Service from 2002 to 2009 with spastic diplegic cerebral palsy, aged 6-12 years, with verbal intelligence (VIQ) or performance intelligence (PIQ) at low average range or above. Child Assessment Service (CAS) of the Department of Health, Hong Kong provides comprehensive assessment service to children aged 0-12 years with developmental problems. Children who could not perform the standardized test in the study, for example : those who failed to write in the dictation in the specific learning difficulty test were excluded. This study was approved by the Ethics Committee of Department of Health of Hong Kong.

Procedures

Written consent was sought from the parents. The subjects attended a 3 hour assessment session on their developmental profile included physical functioning, visual perception, handwriting speed, attention, word learning and self esteem. The assessment team included doctor, clinical psychologist, physiotherapist and occupational therapist.

Measures

Physical functioning : Standardized tests on gross and fine motor functioning were used, these included –

i. Gross Motor Function Classification System (GMFCS)[9,10,11] classifies children with cerebral palsy into 5 levels of functioning according to the abilities of sitting and walking. A Level I child walks without restrictions, a Level II child can walk independently but has limitations walking outdoor and in the community, a Level III child walks with assistive mobility devices, a Level IV child is transported or uses power mobility outdoors and in the community, a Level V child's self mobility is severely limited even with the use of assistive technology.

ii. The Functional Mobility Scale (FMS)[12] is used to describe the functional mobility in children with cerebral palsy aged 4-18 years. It rates walking ability at three specific distances 5, 50 and 500 metres which represents the child's mobility in the home, at school and in the community settings. It also takes into account the range of assistive devices a child might use. Rating of 6 means child walks independent on all surfaces. A child with rating of 5 requires a rail for stairs walking. A child with rating of 4 uses sticks for walking and a rating of 3 if needs crutches instead. If a child uses walker or frame for walking, then a rating of 2 will be given while rating of 1 is for a child who uses wheelchair.

iii. Gross Motor Function Measure (GMFM)[13] is a clinical tool designed to evaluate gross motor function in children with cerebral palsy. GMFM-88 was used. Items span the spectrum from activities in lying and rolling up to walking, running and jumping skills. Total score in % was recorded. 100% means that a child's gross motor functioning is approximately at the level of a normal five years child, able to run, hop and walk stairs without holding on.

iv. Fine motor subtests of Bruininks-Oseretsky Test of Motor Proficiency is a summary of the ability to use the small muscles of the lower arm and hand effectively. These included Subtest 6, 7 and 8 which compile a composite standard scores. Subtest 6 has one item that assesses the ability to respond quickly to a moving stimulus. Subtest 7 has eight items that measure the ability to integrate visual responses with highly controlled motor responses. Subtest 8 has eight items that measure hand and finger dexterity, hand speed and arm speed.

v. Test of Visual Perceptual Skills (non-motor) revised has 7 subtests for assessing different perceptual skills, including visual discrimination, visual memory, visual spatial-relationship, visual form constancy, visual sequential-memory, visual figure ground and visual closure. The perceptual quotient represented the overall performance of these seven perceptual skills.

vi. Handwriting test (CAS) for P.1 to P.4 student and Tsang's Handwriting test[14] for P.5 and P.6 student were used. Children were instructed to copy Chinese paragraph within 5 minutes onto a grid paper. The size of grid was standardized for different grade student.

In order to examine the neuropsychological profile of children with spastic diplegia, the following standardized neuropsychological batteries were used, covering various aspects of higher cognitive functions, involving intellectual functioning, Chinese literacy (reading and dictation), attention, working memory, inhibition, automaticity, and behavior.

i. Word learning: The Literacy subtests of the Hong Kong Test of Specific Learning Difficulties in Reading and Writing for Primary School Students-Second Edition (HKT-P(II)) (2007)[15] were administered to measure the children's Chinese literacy level

including abilities in word recognition, dictation and processing speed of Chinese characters. This test has been widely used in Hong Kong SAR as the diagnostic instrument for dyslexia in local Chinese school-aged children. The participants were asked to read aloud Chinese two-character words in the order of graded difficulty. In the Chinese Word Dictation subtest, participants were asked to dictate Chinese two-character words. In the One-minute reading subtest, the participants were asked to read aloud as quickly and as accurately as possible Chinese two-character words within one minute.

ii. Attention: Three subtests of the Test of Everyday Attention for Children (TEA-Ch) (1999)[16] were administered to examine different facets of attentional control, namely the visual selective attention, sustained auditory attention, and switching attention (inhibitory responses). Local norm was established by the working group of the Hong Kong Psychological Society in 2008[17]. The three subtests were explained as follows:
   - Sky Search: It is a subtest that measures selective attention. It is a timed test that requires participants to find as many as target stimuli in an array of distracters. The second part involves no distracters, so that subtracting part 2 from part 1 gives a measure of a child's ability to make this selection that is relatively free from the influence of motor slowness, so that participants' ability to find the target stimuli would be less confounded with differences in motor speed.
   - Score!: It is a measure of child's ability in self-sustained auditory attention. Participants were asked to keep a count of the number of 'scoring' sounds that they heard on a tape, as if they were keeping the score on a computer game.
   - Creature counting: It is a measure of attentional control/switching. Participants have to switch repeatedly between the two relatively simple activities of counting upwards and counting downwards according to the change of signals in the form of visual cues (arrow up or down). Time taken and accuracy were scored in this subtest.

iii. Inhibition: The Stroop Color-Word Test(2008)[18] was also administered as a measure of ability to suppress or inhibit automatic responses. It is also a supplementary test for selective attention sensitive to frontal lobe function, involving responses inhibition of a dominant reading task in favor of a less dominant color-naming task which includes three conditions (Word condition, Color condition, and Color-Word Condition). Response interference is measured by the difference in time required for naming the ink color of a written color name from the time required to name the dot subtask; this yields the outcome measure. The interference condition result can be interpreted with respect to selective attention and response inhibition. Local normative data for children is established by the Hong Kong Psychological Association (2008)[18].

iv. Automaticity: It is to measure children's efficiency and fluency to decode and retrieve information or simple knowledge they learnt through the following tasks.
   - Rapid digit naming is a cognitive subtest in the Hong Kong Test of Specific Learning Difficulties in Reading and Writing (2007)[15], which purports to measure the rapid naming of numbers. The test is made of five numbers randomly repeated in an array of

eight rows for a total of 40 stimulus items. The participants were asked to name each stimulus item as quickly as possible for two times. Scores were based on the average amount of time required to name all stimuli. The raw scores were then converted to locally normed standardized scores with a mean of 10 (SD=3).

- Verbal Fluency: A Chinese Category Fluency Test(1999)[19] was used. Participants were asked to name their commonly known daily objects (Animals and transportation) as many as possible within one minute of time. The total numbers of names they generated were compared with norm of aged group peers for analysis. It is also a measure of automaticity.
- Working Memory: The Digit Span Test is a supplementary verbal subtest in the Hong Kong Wechsler Intelligence Scale of Intelligence (1981)[20] that measures the span of immediate verbal recall. The test comprises two different tests, Digits Forward and Digits Backward, which involve both auditory attention and short-term retention. The overall performance on both parts was converted to locally normed age-standardized scores with a mean of 10 (SD=3).

v. ADHD Behavioral Rating:
NICHQ Vanderbilt Assessment Scale (2002)[21] was also administered to the parents to obtain their subjective view's on the children's attention and behavioral problems. The NICHQ includes five subscales tapping the parent's rating of the children's behavioral concerns, namely the Inattention Subscale, Hyperactivity Subscale, Oppositional Defiant Subscale, Conduct Disorder Subscale, and Anxiety Disorder Subscale. The items are based on the Diagnostic and Statistical Manual of Mental Disorders (4th ed.) (DSM-IV; American Psychiatric Association, 1994)[22]. In this current study, only the Inattentive Subscale and Hyperactivity/Impulsivity Subscale were analyzed. Parents endorsed 6 out of 9 items on each subscale mean they have worries about the children's attention and behavioral problems in the clinical range of concern. The total raw scores were converted into percentile rank, with a higher percentile rank representing more severe ADHD behavioral manifestation.

vi. Self Esteem:
The Cultural Free Self-esteem Inventory: Third Edition (CFSEI-3) (Battle, 2002)[23] was used to measure different facets of children's sense of well-beings by four subscales, namely Academic, General, Parental/ Home, and Social domains. The Primary Form for children with age-group of 6 to 8 years old (29 items), as well as the Intermediate Form for children with age-group of 9 to 12 years old (64 items) were used. The total scores were converted to obtain a Global Self-Esteem Quotient, and standard scores and percentile rank for the four subscales were also obtained. The Academic Self-Esteem measures an individual's perception of his or her ability to perform academic tasks. The General Self-Esteem measures an individual's overall perceptions of self-worth. Parental/ Home Self-Esteem measures how the individual feels his or her parents or guidance views her. Social Self-Esteem measures an individual's perception of the quality of his or her relationships with peers.

Data Analysis

Upon completion of data collection, the data were encoded for computerized analysis with the use of SPSS for Windows software (version 16.0). Both descriptive and correlational statistics were carried out. For descriptive analysis, aged-scaled scores or percentile ranks were used in all the outcome measures. An independent t-test was conducted to compare the performance on various cognitive tasks between children with spastic dipelgia studying in mainstream and special school for children with physical handicap (PH School). Correlational analysis was conducted to examine the relationship between gross and fine motor functioning with various neuro-cognitive outcomes.

Response Rate

43 children met the inclusion criteria for the study from the CAS cohort. Totally 35 children gave their consents for the study and attended the assessment session. The response rate was 81.4%. 2 subjects were excluded after the assessment session: One child had not attended primary school and therefore failed to complete specific learning difficulty test; the other child with severe visual impairment failed to complete assessment.

Parents who did not give their consent may perceive that their children have less significant problems in their learning and daily living, or they/their child's schedule did not allow them to attend our assessment.

Demographic Data

Among 33 subjects, there were 17 females and 16 males. Their age ranged from 7 to 12 years old (with five 7 year olds, seven 8 year olds, seven 9 year olds, six 10 year olds, seven 11 year olds and one 12 year old). 23 of them were attending mainstream primary school and 10 of them were attending special school for physically handicapped children. In the mainstream school sector, Hong Kong's school system is divided into primary and secondary, with 6 grades in each.

In our cohort, four children attended primary 1, nine children attended primary 2, three children attended primary 3, eight children attended primary 4, seven children attended primary 5 and two children attended primary 6.

Regarding the gestational age and birth weight, 29 out of 33 children were born prematurely, with 23 children born between 24 and 34 weeks of gestation.

8 children have extreme low birth weight (<1kg), 9 have very low birth weight (>1kg to <1.5 kg), 10 have low birth weight (>1.5 kg to <2.5 kg). Only 6 children have normal range birth weight (2.5 to 3.9kg)

Results

Descriptive Data

Gross Motor Functioning

According to GMFCS, 28 out of 33 of the subjects were functioning at Level I and II, and were able to walk without aids most times. There was no Level V children in this group. More detail review according to the Functional Mobility Scale, three of the level II children needed wheelchair for long distance mobility even though they were able to walk in home environment. Most of the children (24 out of 33) attained above 90% in GMFM, lacking only the very advanced activities in the test.)

The gross motor abilities of the subjects were reflected in the scoring of the Gross Motor Function Measure (GMFM). Naturally, subjects studying in mainstream school tend to have better gross motor function with mean scores of 94.64 versus 77.8 for subjects studying in special school. However, the attained GMFM score does not correlate with birth weight, and heavier babies do not necessarily have better gross motor function when they are at primary school years.

Fine Motor Skills

The raw scores were converted to standard scores (have a mean of 15 and a standard deviation of 5) of the same age group. In subtest 6, 64.5% was functioning at low or below average performance. In subtest 7, 48.4% was functioning at low or below average performance. In subtest 8, 74.2% was functioning at low or below average performance. (Table 3)

And 61.3% was below the 16th percentile rank in fine motor composite standard score.

Handwriting Speed

After completion of copying, their speed was compared with peers in the same grade. 67.7% subjects showed slow copying speed (at least 1 SD below mean).

Visual Perceptual Skills

Seven subtests of Test of Visual Perceptual Skills (Revised) were administered for measuring their visual perceptual skills. The raw scores were also converted to scaled score (with mean of 10 and standard deviation of 3). According to the perceptual quotient, more than half of the children had below average visual perceptual performance. Visual closure and visual figure ground were their weakest areas.

	Below average (scaled score < 7)	Average (scaled score >=7)
Visual discrimination	11 (35%)	20 (65%)
Visual memory	17 (55%)	14 (45%)
Visual spatial relationship	12 (39%)	19 (61%)
Visual form constancy	17 (55%)	14 (45%)
Visual sequential memory	11 (35%)	20 (65%)
Visual figure ground	19 (61%)	12 (39%)
Visual closure	20 (65%)	11 (35%)
Perceptual quotient	17 (55%)	14 (45%)

Neurocognitive Functioning

Word Learning

Results revealed that close to 40% and 50% of children with spastic diplegia in our study have significant difficulties in their word recognition ability, as well as processing speed of Chinese characters as revealed in the word reading and one-minute reading subtests. 42% of the subjects have significant difficulty in dictation. About 42% of the subjects performed in the deficit range in their overall Literacy Composite, and similarly 42% of the subjects met the diagnostic criteria of Dyslexia (both scaled score of Literacy Composite and Digit rapid naming <7).

Attention

As compared with the age peers using local standardized norm reference, nearly 70% of children with spastic diplegia in our study performed in the impaired range of their selective visual attention, and close to 50% of subjects fell into the impaired range of their sustained auditory attention. Close to one third of the subjects were impaired in their shifting attention (scaled score <7).

Automaticity & Working Memory

Convergent results indicated that children with spastic diplegia showed problem in their automaticity and working memory. Nearly 76% of subjects in our study presented impairment in their processing speed/automaticity as revealed from the Digit rapid naming task, whereas 36% of the subjects performed in the deficit range in their working memory as revealed from the Digit Span subtest. On the category fluency test, 29 out of 33 subjects (88%) with spastic diplegia in our study performed worse than the age peers, showing their relative weakness in automaticity.

Inhibition

As compared with the age peers using local standardized norm reference, children with spastic diplegia generally performed worse in processing speed of Words and Colors conditions, yet they performed better in the Color condition than their age peers (Word condition: mean scaled score = 6.06, SD = 3.94 ; Color condition: mean scaled score = 7.91; SD = 3.65). However, they did as well as the age peers in the Color-words condition (mean scaled score = 9.42, SD = 3.64). Results also revealed that the interference effect was within normal range as compared with typical age peers (mean scaled score = 10.85, SD = 3.30). It could be understood that the subjects seem to be more able to ignore the interference effect of words, and thus performed as well as age peers in the color-word condition. This did not necessary mean they had better inhibitory control, rather the effect of competing interference of color and word was less compelling.

Behavioral Rating on ADHD Symptoms

Only 31 parents filled out the NICHQ Vanderbilt Assessment Scale. Among them, 7 subjects (21%) with spastic diplegia were rated in the clinical range of concern on the Inattentiveness Subscale, whereas only 1 subject and 3 subjects were rated in the clinical range of concern on the Hyperactivity and Oppositional Subscale respectively.

Self-esteem

6 out of 33 (18%) subjects with spastic diplegia with their Global Self-esteem Quotients (GSEQ) lower than 70, while the majority enjoyed adequate self-esteem within normal range (mean =100, SD =15). 4 out of 33 of subjects reported Low self-esteem (GSEQ = 70 to 79) and two of which reported Very low self-esteem (GSEQ <70). 21 out of the 33 subjects used the Intermediate Form as they fell into the age group of 9 to 12. Further analysis of their self-esteem profile revealed that, relatively more subjects showed concerns over their Academic ability (an individual's perception of his or her ability to perform academic tasks), and General self-esteem (an individual's perception of self-worth), and fewer showed concerns over their Parental and Social Self-Esteem, and the group mean for the Academic Self-Esteem was the lowest as compared with other facets of self-esteem subscales (Mean =7.73, and SD = 3.24).

Discussion:

Our study showed that children with spastic diplegia have increased deficit with gross motor and fine motor skills, visual perceptual skills, selective visual attention, sustained auditory attention, reading, dictation, and processing speed /automaticity.

It is likely that the child's experience and social integration would affect the development of his/her self esteem. It is therefore important that children with spastic diplegic cerebral palsy are supported socially and protected against discrimination.

To ensure the full needs of children with cerebral palsy are met, relevant information regarding a child's physical, psychological and learning profile is important for the child's rehabilitation planning and for him/her to function and participate well in school and society.

A full assessment beyond motor abilities is essential for a child with spastic diplegia. The attention, learning (e.g word learning), visual perceptual skills and self esteem profile of a child with spastic diplegia often differs from that of a normal child. This can be due to underlying brain insult which actually is more extensive than the motor areas. Awareness and understanding of these problems should be actively promoted. Support from the school and community to provide accommodation for these children is as important as treatment for spasticity. The availability of the above information of a child with cerebral palsy can also help with the provision of service such as accommodation and training.

The roles of parents and teachers are very important in the management in cerebral palsy. A comprehensive team approach to assessment and reviewing concerns as raised by parents or teachers across the years will address the developmental needs of these children effectively. Therapists and doctors are encouraged to gain cross discipline knowledge so they may be able to detect symptoms and signs where a child needs expert help from other specialists besides their own field. Interdisciplinary assessments for children with spastic diplegia should be performed if possible.

Direction for future study

With all that in mind, further case controlled studies can be conducted in the above areas for children with spastic diplegia. An additional area, namely language functioning in both receptive and expressive language, in these children may also be explored. The developmental profile of children with other types of cerebral palsy is also worth studying.

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