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Multifaceted Treatment and Therapies in the Care of Children with Cerebral Palsy – A Literature Review

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Abstract

Introduction and Purpose: Cerebral palsy (CP) is a prevalent neurological disorder in children, characterized by movement, muscle tone, and posture impairments. This article reviews the clinical and therapeutic management of CP, focusing on spasticity, musculoskeletal disorders, and holistic rehabilitation. It examines evidence-based interventions, including onabotulinumtoxinA, intrathecal baclofen pumps, and surgical options for orthopedic

deformities. Key rehabilitation techniques such as neurodevelopmental therapies, gait training, and speech therapy are discussed to enhance motor skills and cognitive development. Additionally, the management of associated conditions like epilepsy and intellectual challenges is addressed, emphasizing psychological support for patients and families. The purpose of this article is to provide a comprehensive overview of the current state of knowledge regarding the management of cerebral palsy.

Material and Methods: We utilized English databases such as PubMed, Google Scholar, Cochrane, and PubMed Central, selecting articles based on keywords like cerebral palsy, spasticity, physical therapy, and rehabilitation.

State of Knowledge: Effective CP management requires a multidisciplinary approach to tackle motor impairments, spasticity, deformities, and psychosocial challenges. Therapeutic interventions, including pharmacological treatments, surgical options, and innovative rehabilitation techniques, are essential for improving mobility and quality of life.

Summary: Comprehensive care for children with CP is crucial. Evidence supports combining multiple therapeutic approaches tailored to each child's needs and involving family preferences to optimize development and well-being.

Keywords: cerebral palsy; spasticity; rehabilitation.

Introduction:

Cerebral palsy is a group of symptoms characterized by disturbances in movement, posture, and balance. Among children with motor disabilities, cerebral palsy is the most commonly diagnosed condition, with an incidence of 2-2.5 per 1,000 live births [1]. It is caused by permanent, non-progressive brain damage that most often occurs during the prenatal period but can also happen perinatally or postnatally [2].

Patients with cerebral palsy frequently experience muscle spasticity as well as difficulties with swallowing, speech, epilepsy, intellectual delays, and psychosocial problems [3]. Due to these challenges, it is crucial to provide these children with comprehensive care as early as possible.

Early intervention is especially important because of the brain's plasticity at such a young age, which can significantly improve their quality of life [4].

The ultimate goal is to ensure that children with cerebral palsy receive comprehensive, evidence-based care tailored to their specific needs, while also considering the preferences and values of their families [5].

1. Spasticity treatment

Spasticity can be described as „a motor disorder characterized by a velocity-dependent increase in tonic stretch reflexes (muscle tone) with exaggerated tendon jerks, resulting from hyperexcitability of the stretch reflex, as one component of the upper motor neuron syndrome" [6]. This symptom occurs in approximately two-thirds of children with cerebral palsy and is more commonly associated with the lower limbs than the upper limbs [7]. Managing spasticity is crucial not only for relieving pain and preserving function, but also for preventing and correcting bone and joint deformities caused by spasticity [3]. Pharmacologic treatment with muscle relaxants and non-drug approaches like rehabilitation therapy have been key components in managing spasticity [8,9].

1.1 OnabotulinumtoxinA

OnabotulinumtoxinA, also known as Botox, has been used in the treatment of spasticity for many years. It works by inhibiting the release of acetylcholine from neuromuscular synapses. This lack of muscle stimulation results in reduced muscle tone [10]. This treatment can be initiated between 18 and 24 months of age [11]. The registration studies for this drug, concerning both lower limbs [12] and upper limbs [13], were international, multicenter, randomized, double-blind, placebo-controlled, 12-week phase 3 studies. In the study related to the treatment of the lower limb, injections were administered into the gastrocnemius, soleus, and tibialis posterior muscles, while in the study on the upper limb, a single muscle group was injected. Both studies demonstrated the efficacy and safety of botulinum toxin in the treatment of spasticity in the pediatric population, proving to be more effective than placebo [12,13].

1.2 Oral antispasticity medications

Oral antispasticity medications are convenient to use but have systemic effects and significant side effects, making them suitable for children who need only mild tone reduction or have widespread spasticity. Most studies on their effectiveness are outdated and lack the rigorous designs used in modern research. As a result, the choice of medication is often based on personal

experience or trial and error rather than strong evidence. Common oral medications, such as benzodiazepines, dantrolene, baclofen, and tizanidine, can be combined to improve clinical outcomes and reduce side effects. These medications can also be used alongside other treatments like neuromuscular blocking agents or intrathecal baclofen [14].

Benzodiazepines, such as diazepam, reduce spasticity by enhancing GABA's effect on $GABA_A$ receptors at both spinal and supraspinal levels [15]. Diazepam is commonly used, but its side effects, like sedation, limit dosage, and long-term use can lead to physical dependence [16].

Dantrolene sodium works by inhibiting calcium release in muscles, but it can cause weakness and sedation. It is rarely used due to concerns about hepatotoxicity and limited supporting evidence [17].

Baclofen, a GABA agonist, binds to $GABA_B$ receptors in the spinal cord, reducing spasticity. Its side effects include sedation and confusion, and it must be weaned off gradually to prevent withdrawal symptoms [17].

Tizanidine is an alpha-2 adrenergic agonist that helps lower muscle tone and also has a pain-relieving effect. Its use is limited by the need for frequent dosing and its sedative properties. However, the sedation can be beneficial when administered at night [16].

1.3 Selective Dorsal Rhizotomy

Selective Dorsal Rhizotomy is a neurosurgical procedure where specific nerve roots are cut to decrease spasticity and enhance motor control [18]. It is more effective when performed in early childhood, as it trains new gait patterns in the absence of spasticity.

If done too late, secondary contractures may develop, reducing its effectiveness. Studies show that SDR benefits children aged 4 to 10 [19], but older patients (ages 10-20) often experience functional declines [20].

1.4 Intrathecal Baclofen Pump Implantation

Intrathecal baclofen (ITB) treatment is a method that involves the direct infusion of baclofen into the spinal canal and around the spinal cord using a specialized pump and catheter system [21]. It is used to treat more widespread spasticity [9]. Research with with a high level of scientific evidence has shown that intrathecal baclofen (ITB) is the most effective treatment for spasticity in children with cerebral palsy classified as GMFCS grades IV and V [22].

By infusing baclofen directly into the space around the spinal cord, spasticity is reduced with fewer brain-related side effects compared to oral baclofen, which can cause sedation [23]. However, it comes at a high cost, needs regular refills, is invasive, and poses a higher risk of infections and surgical complications compared to alternative treatments [24].

2. Management of Musculoskeletal and Functional Disorders

Children with CP often experience various orthopedic complications that can affect their mobility and quality of life. This section reviews key issues related to hip displacement, foot and ankle deformities, hand dysfunction, and balance and movement disorders in children with cerebral palsy, highlighting the recommended therapeutic approaches and surgical interventions. Understanding these aspects is essential for developing individualized treatment plans that address each child's unique needs and optimize their potential for mobility and independence [3,4].

2.1 Hip Deformities treatment

Hip displacement affects over a third of children with cerebral palsy, with a higher incidence among those who are not able to walk. This condition often worsens over time, progressing from hip subluxation to full dislocation [25]. Since the early stages of hip displacement may not show any symptoms, hip surveillance programs are recommended to ensure early detection and management of hip issues. The choice of treatment for hip disorders depends on factors such as the severity of the hip disorder, the patient's level of function, and their age. Surgical options include preventive, reconstructive, and salvage procedures. Introducing hip surveillance programs has led to a reduction in the need for salvage surgeries in children with cerebral palsy [26].

2.2 Foot and Ankle Deformities

Foot and ankle deformities in children with cerebral palsy often result from dynamic muscle imbalance and abnormal biomechanics, gradually worsening over time. As these deformities progress, they can cause pain, affect walking, and complicate the use of braces [27,28]. Treatment typically involves a combination of orthotics, physical therapy, spasticity management, and surgical correction. The treatment approach is individualized and takes multiple factors into account. Key considerations include the child's functional level, the

severity and flexibility of the deformity, the presence of pain or skin irritation, and any changes in alignment over time [27-29].

Assessing foot deformities in these patients involves a comprehensive approach, including clinical history, physical examinations, gait analysis, and imaging. When surgery is necessary, evaluating the deformities under anesthesia helps to differentiate between dynamic issues and fixed contractures. Surgical treatment is individualized based on the patient's specific condition, focusing on correcting joint and skeletal malalignments [27,28].

Equinus deformity, characterized by excessive plantar flexion, is a common issue, and its treatment depends on understanding the extent of the contracture. Flatfoot is more frequent in children with spastic diplegia or quadriplegia and presents with a variety of foot misalignments. Equinovarus, which involves multiple levels of foot misalignment, is more common in children with spastic hemiplegia or quadriplegia. Hallux valgus and dorsal bunions are also observed, particularly in older children with a spastic motor disorder [28].

The primary aim of surgical treatment is to improve the foot's shape and its shock-absorbing ability by correcting both within-segment and between-segment misalignments. During surgery, it is crucial to address all areas of misalignment by realigning the joints through soft-tissue releases, fixing bone deformities, and balancing the muscles properly [28,29].

2.3 Hand dysfunction

Hand dysfunction due to brain injury can lead to disturbances in hand functioning, which may affect one side (unilateral) [30] or both sides (bilateral) of the body [31]. In cases of unilateral cerebral palsy (CP), motor control and function are impaired on one side, leading to difficulties in using the affected hand [30].

Constraint-Induced Movement Therapy (CIMT) is a therapeutic approach designed to enhance the function of the affected hand. This technique works on the principle that restricting the use of the unaffected hand and encouraging the intensive use of the affected hand promotes neuroplasticity in the brain, ultimately improving hand function [32].

CIMT has been well-documented in the literature as an effective strategy to improve hand function. However, its impact on muscle tone and protective extension is still under investigation. CIMT has also been found to enhance somatosensory function and neural processing in children with hemiplegic cerebral palsy [32].

Hand-Arm Bimanual Intensive Therapy (HABIT) is another therapeutic technique aimed at improving hand function. Unlike CIMT, HABIT focuses on the coordinated use of both hands [33]. Studies have shown that both CIMT and HABIT are promising methods for enhancing

hand function in children with hemiplegic cerebral palsy. However, HABIT may be more tolerable for children, especially those who become frustrated with the limitations imposed by CIMT [32,34].

2.4 Balance and Movement Disorders

Balance and movement disorders are key challenges in managing cerebral palsy (CP) in children, as they are crucial for maximizing activities of daily living. Early referral to physical and occupational therapies is recommended as soon as CP is diagnosed [35]. Traditional management strategies include a variety of therapies such as physiotherapy, occupational therapy, hyperbaric oxygen therapy, sensory integration, Neurodevelopmental Treatment (NDT), hippotherapy, Constraint-Induced Movement Therapy (CIMT), Body-Weight Supported Treadmill Training (BWSTT) and the Vojta method [11, 35]. The use of onabotulinumtoxinA injections as an adjunct to therapy may further enhance motor function in suitable patients [36].

3. Comprehensive Rehabilitation

Motor problems are just one of the many challenges faced by individuals with cerebral palsy (CP). They often also experience difficulties related to speech, coordination, perception, and cognitive abilities [3,11]. Therefore, rehabilitation in their case is a multi-level process that includes various therapeutic methods aimed not only at improving mobility but also at enhancing cognitive, communicative, and social functions. Depending on the individual needs of the patient, different forms of therapy are available that can significantly support the process of treatment and adaptation to everyday challenges [4].

3.1 The Bobath approach

The NDT (Neurodevelopmental Therapy) Bobath approach is frequently used to treat neuroplasticity challenges in children with cerebral palsy (CP). It is based on the belief that irregularities in postural control and reflexes, resulting from central nervous system dysfunction, contribute to motor difficulties. The primary objective of NDT Bobath therapy is to encourage proper motor development, prevent muscle contractures and joint deformities, and improve body stability and alignment. This is achieved through exercises mainly targeting the extensor muscles of the lower limbs, particularly around the hip region [37]. Despite its clinical use, there is limited evidence of its effectiveness, indicating a need for better evaluation methods [38].

3.2 Vojta therapy

Vojta therapy focuses on encouraging proper movement patterns in newborns and infants with central nervous system disorders. It aims to promote automatic coordination of body positions and movements, ensuring that the limbs and trunk move in well-defined, reciprocal patterns [37]. This therapy works by stimulating specific areas to induce psychomotor changes, helping to suppress abnormal movements and encourage normal motor development while also enhancing postural control. The goal is to reduce compensatory movements that the patient may have developed improperly [39].

3.3 Strength training

Based on the findings of the article "Effect of Muscle Strength Training in Children and Adolescents with Spastic Cerebral Palsy: A Systematic Review and Meta-Analysis," strength training in children and adolescents with cerebral palsy positively impacts muscle strength in the lower limbs, gait speed, standing balance, and gross motor function, without affecting spasticity. However, these benefits are short-term, necessitating regular, high-intensity training to maintain and enhance the effects. Strength training should be part of a comprehensive program that includes motor skill and endurance training for optimal results [40].

3.4 Action observation treatment (AOT)

Action observation treatment (AOT) is a rehabilitation technique that focuses on improving motor skills by having individuals observe specific movements performed by others and then try to replicate them [41]. In practice, for children with cerebral palsy (CP), the therapy involves watching video clips showing daily activities that require the use of the arms and hands (e.g., grasping objects, using a pencil, or playing with toys). After observing these actions, the children are asked to imitate them. The aim of AOT is to stimulate the brain regions involved in movement, which helps improve the functioning of the upper limbs and enhances the child's ability to perform everyday tasks [41,42].

3.5 Task-specific training (TST)

Task-specific training (TST) is a form of rehabilitation that focuses on practicing specific tasks that are directly related to the child's functional goals. The idea is to improve the child's ability to perform daily activities by repeatedly practicing tasks that they would encounter in their real-life environment. For children with cerebral palsy (CP), this might include activities like walking, climbing stairs, or standing up from a seated position [43]. This therapy is typically customized to meet the unique needs and capabilities of each child, considering their particular gross motor function level and developmental stage [43, 44].

3.6 Functional gait training (FGT)

Functional gait training (FGT) is a rehabilitation approach designed to enhance walking ability and mobility. It emphasizes the active practice of walking through various methods, including overground gait training and treadmill-based gait training [45].

A complementary technique, robotic-assisted gait training (RAGT), further improves walking practice by utilizing robotic devices for mechanical support. This method is particularly advantageous for children who face challenges in generating the necessary movements or repetitions required for progress in their walking ability [46].

3.7 Hippotherapy

Hippotherapy is a therapeutic approach that utilizes the unique movements of a horse to deliver targeted motor and sensory input. The horse's rhythmic, three-dimensional movements, which mimic human gait, stimulate balance and improve postural stability [47]. Research has demonstrated significant improvements in gross motor skills, balance, and a reduction in muscle spasticity among children with cerebral palsy who participate in hippotherapy. Evidence suggests that sessions lasting 30 to 45 minutes, conducted twice weekly over a period of 8 to 12 weeks, can result in meaningful benefits for motor function [48].

3.8 Therapeutic Approaches to Speech and Feeding Challenges

Children with cerebral palsy (CP) often experience various levels of speech and feeding impairments, which can significantly affect their quality of life. These challenges include difficulties with drooling, swallowing, and feeding, impacting approximately 44.0%, 50.4%, and 53.5% of children with CP, respectively. In fact, about half of all children with cerebral palsy struggle with speech-related difficulties [49]. Speech therapy plays a crucial role in addressing these issues by improving oral motor skills, enhancing speech articulation, and developing overall communication abilities [3 ,49].

Additionally, children with CP frequently encounter significant nutritional problems, affecting between 30% and 90% of this population, with malnutrition present in up to 90% of cases. The primary causes of these nutritional difficulties include oral motor dysfunction, postural challenges, persistence of primitive reflexes, chewing disorders, and drooling [50].

One of the contributing factors is tongue thrust, an oral reflex associated with sucking, which can hinder swallowing, speech, and oro-facial development. To address these complex challenges, a therapeutic approach called Functional Chewing Training (FuCT) has been developed [51]. FuCT focuses on improving chewing function and tongue control in children

with CP by emphasizing proper positioning of the child and food, sensory stimulation, and motor training techniques. This therapy helps restore and enhance tongue function, making it a valuable intervention within the broader scope of speech therapy for these children [51, 52].

4. Epilepsy management

Epilepsy is frequently listed among the many symptoms seen in patients with cerebral palsy, affecting between 15% and 55% of children and adults with the condition [53]. Its presence is associated with an increased risk of cognitive problems and makes caregiving for the affected child more challenging [54]. Seizures associated with CP are likely to recur, so early treatment is advised, especially if EEG shows epileptic activity. The choice of treatment is mainly guided by the type of seizure and the specific epileptic syndrome [53].

5. The intellectual development managment

The intellectual development of children with CP can be highly variable. Some children experience cognitive development within the normal range, while others may face difficulties with learning, concentration, or information processing [55]. Children with CP often require an individualized educational approach that takes into account their specific needs. Sensory integration, occupational therapy, and teaching methods tailored to the child's intellectual level can significantly improve educational outcomes and support cognitive development [56].

6. Psychological Support for Patients and Their Families

Children with cerebral palsy often face numerous physical limitations and difficulties in performing daily activities [57, 58]. These challenges can lead to frustration, feelings of helplessness, and low self-esteem. As a result, these children are more susceptible to anxiety, depression, and feelings of social isolation. Therefore, it is essential to diagnose these issues at an early stage to ensure that children have access to necessary resources and therapies. One therapeutic approach is cognitive-behavioral therapy, which helps children identify and change negative thoughts and behaviors [57].

Parenting a child with cerebral palsy is often isolating and stressful, which underscores the importance of supporting parents to optimize their child's development while also safeguarding the parents' mental health. Recent empirical evidence supports the effectiveness of two interventions designed for parents of children with cerebral palsy: Stepping Stones Triple P and Acceptance and Commitment Therapy (ACT) [58].

Stepping Stones Triple P aims to enhance parenting skills, providing strategies to manage the unique challenges faced by these families. In contrast, ACT focuses on increasing parental flexibility and helping parents effectively utilize their parenting skills in stressful situations [58].

Summary

Cerebral palsy is a multifaceted condition that requires a holistic approach to management, involving both medical and therapeutic interventions. The goal is to tailor care plans that address the specific needs of each child while considering their family's preferences [5]. From managing spasticity [3] and orthopedic complications [4] to addressing cognitive [55] and psychological challenges [57], providing individualized, evidence-based care can significantly improve outcomes and quality of life for children with CP and their families. Early intervention and consistent support remain crucial in maximizing the potential for mobility, communication, and overall well-being, empowering these children to lead more fulfilling lives [4].

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