Effective Physical Therapy Rehabilitation of Perinatal Stroke

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Abstract

This paper defines perinatal stroke and discusses various complementary rehabilitation techniques for young survivors of perinatal stroke who present with cerebral palsy (specifically hemiplegia and spasticity). Based on the relatively new nature of perinatal stroke rehabilitation, I hypothesize that further research will be required before a definitive treatment preference can be determined. This paper evaluates the effectiveness of constraint-induced movement therapy, botulinum toxin A injections, virtual reality exercise, conductive education, modified Adeli suit exercise, and aquatic therapy, and attempts to define the most effective rehabilitation techniques for maximizing patient function. It concludes that botulinum toxin A injections, virtual reality exercise, conductive education, modified Adeli suit therapy, and aquatic therapy require more research before they can be used as regular complementary treatments for cerebral palsy. However, constraint-induced movement therapy has long been known to provide successful outcomes regarding muscle movement and strength return, and is currently considered the most effective complementary therapy for this population.

**Keywords:** perinatal stroke, cerebral palsy, constraint-induced movement therapy, botulinum toxin A, virtual reality exercise, conductive education, modified Adeli suit therapy, aquatic therapy, rehabilitation, spasticity, hemiplegia
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Introduction and Overview of Perinatal Stroke

Perinatal strokes are cerebrovascular events that occur between 20 weeks gestation and 28 weeks postnatal life, most often caused by underlying cardiac disease, blood vessel abnormalities, and/or clotting disorders (Cleveland Clinic, 2010). Perinatal strokes occur in about 1 in every 4000 live births, and are one of the main causes of cerebral palsy in children. Symptoms of perinatal stroke include seizure, significant perinatal distress, apnea, pathological early hand preference, and developmental delay (Lee et al., 2010) (Roach et al., 2008). When perinatal strokes lead to cerebral palsy, hemiplegia and hemiparesis are the most common subtypes (87%) (Golomb, 2009).

Cerebral palsy can cause a number of secondary health issues. Therefore, rehabilitation services must be started as soon after the diagnosis as possible. The majority of treatments for motor rehabilitation following perinatal stroke focus on “minimizing spasticity and maximizing range of motion and function” (Golomb, 2009), as well as decreasing pain and the risk of secondary complications (Bjornson et al., 2007). A standard physical therapy treatment protocol for cerebral palsy includes vigorous muscle stretching, resistance training, regular weight bearing through the legs, and cardiovascular exercise (Damiano, 2006). However, many children with cerebral palsy receive additional therapies to complement the standard physical therapy regimen. These therapies must also be considered as early in the rehabilitation process as possible.

Literature Review of Complementary Rehabilitation Techniques

There are currently six main complementary treatments for perinatal stroke. These include constraint-induced movement therapy, botulinum toxin A injections, virtual reality exercise, conductive education, Adeli suit therapy, and aquatic therapy. These methods are able
to benefit the patients in ways that traditional treatment techniques cannot, and must be carefully considered for patients on individual bases.

**Constraint-induced movement (CI) therapy**

All forms of CI therapy include three main components – “intensive training of the more affected extremity, prolonged restraint of the less affected extremity, and a transfer package of techniques to induce transfer of therapeutic gains achieved in the laboratory” to more practical situations (Taub, Ramey, DeLuca, & Echols, 2004). CI therapy is mainly used to treat the upper extremities. It should be noted that CI therapy is very rarely used to treat hemiplegia, but it has been found to be useful in treating hemiparesis.

**Findings.** Results of CI therapy are even more favorable for the pediatric population than for adults (Taub et al., 2007). One study found that pediatric CI therapy resulted in significant and sustained improvement in motor function of children with hemiparesis (Taub et al., 2004). This study found the average retention at six months post-CI therapy to be 70% (Taub et al., 2007). Children who received therapy acquired more new motor skills, demonstrated bigger gains in the amount and quality of arm movement, and showed more improvement in unprompted arm use than children who were not treated with CI therapy.

Unfortunately, CI therapy is poorly tolerated by toddlers and children (Golomb, 2009). CI therapy can be very frustrating and discouraging for young patients and their parents, and therefore may not be the best course of treatment for children who are unable to understand the purpose of the therapy. Additionally, CI therapy does not have immediate effects. It requires significant cost-benefit analysis, and the medical team and parents need to decide whether the frustration associated with CI therapy is in the child’s best interests. It should be noted that
results of pediatric CI therapy are often limited by the parents’ compliance with therapeutic post-treatment suggestions (Taub et al., 2007).

**Conclusion.** CI therapy can be very beneficial for young children with hemiplegia who can tolerate prolonged non-use of the preferred side. It specifically improves motor skills related to unprompted arm movement, and have prolonged effects.

**Botulinum toxin A (BT) injections**

Botulinum toxin A injections are not currently approved by the FDA to treat pediatric spasticity. Regardless, they are commonly used to block nerve signals to spastic muscles by blocking acetylcholine release.

**Findings.** BT injections are most successful when combined with physical therapy and casting (Dressier, 2012), and when started at a young age (Hillis & Jordan, 2011). Researchers have seen significant decreases in spasticity 3, 8, and 12 weeks post-injection, improved performance goals 12 weeks after injection, and improved gross motor function 24 weeks post-injection (Bjornson et al., 2007). In another study, muscle tone and gait were improved 3 and 6 months after serial injections (Wang & Gao, 2013). It is known that results are transient and only last for a few months. Therefore, serial injections are required for long-term effects (Wang & Gao, 2013).

Unfortunately, BT injections may have systemic adverse effects such as flu-like symptoms, headaches, light-headedness, fever, chills, hypertension, diarrhea, abdominal pain, weakness, dysphagia, dry mouth, and aspiration, (Dahan-Oliel, Kasaai, Montpetit, & Hamdy, 2012), but these effects do not last (Bjornson et al., 2007). Minor reactions include bruising and pain at the injection site, localized muscle weakness, and incontinence (Dahan-Oliel et al., 2012).
Drug resistance may also occur (Dahan-Oliel et al., 2012). Because it is a relatively new drug, it is unknown whether botulinum toxin A has any long-term negative effects.

**Conclusion.** Overall, BT works to reduce muscle tone, increase function, prevent contractures, manage pain, and increase quality of life (Golomb, 2009) (Dahan-Oliel et al., 2012). However, there is still a lack of research to determine proper dosage and treatment regimens (Friedman & Goldman, 2011). Because the majority of current research on BT injections is on lower extremity spasticity, further research is also required to determine the efficacy of BT injections on the upper extremities.

**Virtual reality exercise**

Virtual reality videogame exercises are becoming a more popular complementary treatment for hemiparesis. Virtual reality exercise encourages the use of the more affected arm. The rehabilitative games are simple, and even the smallest of hand movements are promoted in order to have positive outcomes (and therefore positive feedback) on the screen. Not only does the gaming aspect of the treatment make it enjoyable, but virtual reality exercise is also accessible in the home and convenient for patients who live far from rehabilitative centers.

**Findings.** Evidence indicates that virtual reality exercise can assist in the recovery of motor skills in adult patients following stroke by creating an interactive and motivating environment in which intensity and feedback can be manipulated. This allows treatments to be individualized (Merians et al., 2002), and allows patients to use the feedback to gear their future performance. The research on adults has shown that virtual reality exercise can increase strength, range of motion, and speed, and these improvements were seen to transfer to increased function (Merians et al., 2002). Despite roadblocks, one of the first studies on pediatric telerehabilitation found positive outcomes in all three subjects (Golomb & Barkat-Masih, 2009).
There are no harms associated with virtual reality exercise. It offers convenience that most methods of treatment do not. However, because virtual reality exercise is aimed towards those who do not have direct access to physical therapy clinics, these users may inherently have less contact with physical therapists.

**Conclusion.** Virtual reality exercise is currently being tested for rehabilitation of pediatric hemiplegia, and is showing promise (Golomb & Barkat-Masih, 2009). However, further research is required for virtual reality exercise to be considered an effective treatment for pediatric hemiparetic cerebral palsy.

**Conductive education (CE)**

There are four main elements of conductive education – “task-oriented learning…; facilitating and commenting on motor actions by rhythmic intending…; integration of manual abilities into the context of ADLs; and child-oriented group settings to facilitate psychosocial learning to increase the level of participation” (Blank, von Kries, Hesse, & von Voss, 2008). The group setting stems from the idea that as the group works collectively, “each child’s progress assists the performance of others (Reddihough, King, Coleman, & Catanese, 1998). This type of therapy can be beneficial for children with many symptoms stemming from cerebral palsy, as it is not solely aimed towards those with cognitive, motor, social, or speech impairments.

**Findings.** Studies on the effects of conductive education have found conflicting results. A study by Blank, von Kries, Hesse, and von Voss (2008) found that “conductive education improved hand function by 20% to 25%” and improved ADL competence, but did not improve elementary hand functions. Another study comparison found that children with cerebral palsy
made similar developmental gains regardless of the type of therapy in which they were enrolled (CE-based vs. traditional) (Reddihough, 1998).

While many children will find the group nature engaging, others (especially those with sensory or behavioral deficits) may find it distracting. Fortunately, there are no serious adverse effects of conductive education.

**Conclusion.** Due to conflicting study results, a more comprehensive study on conductive education must be done in order to conclude that conductive education is an appropriate complementary therapy for children with hemiparetic cerebral palsy.

**Modified Adeli suit therapy (MAST)**

The Adeli suit is a system of supporting elements such as vests, shorts, and footwear that makes it difficult for the patient to move without restricting the amplitudes of the desired movements (Mahani, Karimloo, & Amirsalari, 2011). Adeli suit therapy (AST) is based on three principles – 1) the effects of working against resistance loads increases proprioception and improves alignment; 2) therapy for 1 month, at least 2 hours/day, 5 days/week; and 3) active motor participation of the patient (Mahani, 2011). The inventor of the Adeli suit argued that the suit would “reduce pathological synergies, improve normal muscular synergies, and apply loads to antigravity musculatures to lead to normalization of the afferent vestibulo-proprioceptive input” (Mahani, 2011). Because AST can be tedious, is not ideal for children. Therefore, the modified AST (MAST) came about to apply joyful and purposeful activities to maximize the Adeli suit’s effect on children.

**Findings.** Not only does the Adeli suit aid in strengthening in general, it also normalizes and enforces the flow of afferent impulses by actively correcting position to directly influence impaired brain kinetic centers (Mahani, 2011). A study done at the Children’s Hospital of
Michigan found consistent improvement in both the control group and the treatment group, and greater improvement in some functions for the treatment group. However, there was no statistical difference between the results of the two groups (Mahani, 2011). Aside from the cumbersome nature of the Adeli suit, there are no significant adverse effects of MAST.

**Conclusion.** MAST has significant potential to benefit children with hemiparetic cerebral palsy. Despite it’s potential, results show that MAST has the same rehabilitative effect as traditional therapy. Further research is needed before MAST can be suggested as a routine treatment for children with hemiparetic cerebral palsy.

**Aquatic therapy**

Aquatic therapy is a common complementary treatment for cerebral palsy. Three factors must be considered when implementing aquatic therapy – “ensuring adequate intensity, duration, and frequency to promote a fitness effect; determining when a group environment may be more beneficial than individual interventions; and making sure that the pool environment is suitable and safe for intervention” (Kelly and Darrah, 2005).

**Findings.** Warm water allows for muscle relaxation, helps to increase range of motion, and decreases pain. Water minimizes the effects of gravity, which reduces impact and joint loading. It also provides increased postural support that children with cerebral palsy often lack. Water provides 14 times more somatosensory information than air does, and stimulates the skin, vestibular system, visual system, and inner ear. Water can also be used to help treat the cardiovascular and oromotor systems if breath holds and/or bubble blowing are implemented within therapy. Water also allows children with neuromotor disorders to move at a faster pace than on land, which can challenge their cardiovascular systems (Viguers, 2010).
While the pool environment is generally safe for children with hemiparetic cerebral palsy, it can be a hazard for children who have secondary diagnoses such as open wounds, tracheotomies, and chest tubes.

**Conclusion.** The large scope of benefit associated with aquatic therapy makes it an ideal therapy that focuses on many aspects of cerebral palsy. However, further evidence is needed regarding the effects of aquatic therapy on the management of cerebral palsy (Kelly and Darrah, 2005).

**Conclusion**

More research must be done before botulinum toxin A injections, virtual reality exercise, conductive education, modified Adeli suit therapy, and aquatic therapy can be approved for use as regular treatment of cerebral palsy. Constraint-induced movement therapy is the most beneficial complementary treatment for hemiparesis caused by cerebral palsy (due to perinatal stroke or otherwise). Significant research has been done on the outcomes following CI therapy, ensuring that it is a safe and effective method of rehabilitation for children with hemiparesis.
References


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