International Handbook of Occupational Therapy Interventions

Chapter 35
Upper-Limb Movement Training in Children Following Injection of Botulinum Neurotoxin A

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After injection and intensive therapy, the client was really happy to be able to catch and throw a ball with his school friends.

Abstract Botulinum Neurotoxin A (BoNT-A) is a useful medication for the reduction of spasticity and dystonia in the upper limb of children with cerebral palsy (CP). The method of toxin delivery, dose, and muscle selection criteria are established. Children who are being treated require appropriate assessment at the impairment and activity levels of functioning. Once injected, children require specific therapy delivered by an occupational therapist (OT) according to the specified goals of the intervention set out, prior to injection, by the child, family, and health care workers. Botulinum neurotoxin injection offers the child with cerebral palsy a window of opportunity in which to develop further skills in upper limb functioning. Further research using rigorous scientific design evaluating specific therapy regimes and other interventions is required to enable more specific protocols to be established.

Keywords Botulinum Neurotoxin • Child • Cerebral palsy • Upper limb

Definition and Background

Cerebral palsy is a static lesion of the immature brain (Taft, 1995) leading to disorders of tone, posture, and movement (Bax et al., 2005). Affected children can experience varying degrees of positive (e.g., increased tone) and negative (e.g., sensory impairment) features of the disorder, and each can have impact on functioning (Graham, 2000). The predominant disorders of tone in cerebral palsy are *spasticity* (Graham, 2000) and *dystonia* (Autti-Ramo et al., 2001). The topography of involvement can affect the upper limb in children with all forms of cerebral palsy, and impact on function.

Both spasticity and dystonia can be influenced by botulinum Neurotoxin A (BoNT-A) injection (Brin, 1997).

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BoNT-A is a protein product of *Clostridium botulinum*, an anaerobic bacterium (Jankovic and Brin, 1997). Its action is to block the release of acetylcholine from the motor nerve terminal to the muscle cell, causing a chemical denervation (Brin, 1997). The pharmacologic effect of BoNT-A lasts up to 12 weeks (Graham, 2000); however, functional benefits lasting much longer can be experienced (Lowe et al., 2006; Russo et al., 2007).

BoNT-A is injected directly into the affected muscles, which are targeted according to clinical evaluation and desired functional goals (Russman et al., 1997). In the upper limb these muscles usually include the elbow flexors, wrist flexors, pronators, thumb adductor and opponens, and finger flexors (Lowe et al., 2006; Russman et al., 1997). Dosing regimes and dilution volumes for BoNT-A are established (Russman et al., 1997). The child usually has some form of analgesia for the procedure (Lowe et al., 2006; Russman et al., 1997; Russo et al., 2007), and the muscles to be injected are usually identified by surface anatomy, palpation, and some form of localization (such as with a stimulator, electromyography, or ultrasound) to ensure correct needle placement (O'Brien, 1997).

Purpose

BoNT-A injected directly into the affected muscle results in relaxation of the muscle, providing a window of opportunity to allow for therapy intervention.The overall aim of the occupational therapy intervention in children with cerebral paresis is to improve occupational performance, and whatever changes are achieved in capacity are best achieved in the context of improving skills (Kielhofner, 1995).

Method

Candidates for the Intervention

For children with cerebral palsy with *more severe upper limb impairment* (i.e., Manual Ability Classification System [MACS] level IV to V) (Eliasson et al., 2006), BoNT-A is injected to reduce muscle spasticity and muscle tone, increase range of motion, improve agonist-antagonist balance, delay the need for or complement orthopedic procedures, improve tolerance to splinting, maintain hygiene and skin integrity, improve cosmesis, manage pain, and prevent long-term deformity.

For children with *less severe upper limb impairment* (i.e., MACS level I to III) (Eliasson et al., 2006), hand skill development, improved occupational performance, and functional goal attainment are often the goals for treatment.

Epidemiology

Cerebral palsy occurs with an incidence of approximately 2 to 2.5 per 1000 live births (Reddihough and Collins, 2003). Upon careful and thorough clinical assessment, it is estimated that up to 50% of the population of children with cerebral palsy will benefit from upper limb injection of Botulinum Neurotoxin A.

The Role of the Occupational Therapist in Applying the Intervention

The role of the occupational therapist (OT) is integral in the identification of appropriate children for Botulinum Neurotoxin A injection, the selection of muscles for injection, pre- and postinjection assessment, goal setting, and the provision of adjunct interventions following injection.

Results

Clinical Application

Assessment of the Upper Limb Before Injection of BoNT-A

Assessment of impairment level should occur in larger muscle groups in the upper limb in children who receive BoNT-A injection. These measures assist in (1) identifying muscles with significant spasticity interfering with function, (2) selecting the muscle for injection, (3) determining the dosage, and (4) choosing the direction of the postinjection therapy.

Clinical range of motion is measured together with spasticity using the modified Tardieu scale (Boyd and Graham, 1999; Mackey, et al., 2004). This measure of spasticity is obtained when a joint is moved as fast as possible through its range of movement (V3 velocity) and the angle of “catch” elicited is measured using a goniometer. The difference between the angle of “catch” (R1) and the full passive range of movement (R2) reflects the potential range available in the joint if spasticity is eliminated.

Assessment of activity level requires careful observation of how spasticity and dystonia impact on the child’s task performance. Videotaped assessments such as the Melbourne Assessment of Unilateral Upper Limb Function (Randall et al., 2001) and the Assisting Hand Assessment (Krumlinde-Sundholm et al., 2007) provide valuable information on a child’s typical movement abilities. These observations are critical for (1) guiding muscle selection, (2) directing postinjection therapy, and (3) providing objective data measuring the change postinjection.

Goal Setting

The Canadian Occupational Performance Measure (COPM) (Law et al., 1994) is designed to detect change in a person's occupational performance. The COPM is an extremely useful tool for identifying and prioritizing goals pre- and postinjection of BoNT-A. The COPM responses can be transferred and scaled using the Goal Attainment Scaling (Kiresuk et al, 1994). This complementary approach enables goal identification, articulation, and measurement (Lowe et al., 2006; Wallen et al., 2007).

Intervention Postinjection of BoNT-A

Impairment Level: Stretching and Splinting

Active or passive manipulation of a muscle for 20 minutes immediately postinjection increases the efficacy of BoNT-A in the injected muscle and reduces diffusion to distant muscles (Minamoto et al., 2007). It is therefore important to provide immediate stretch to the child postinjection by applying a splint or encouraging active movement.

The general recommendation for *splint use* is for a minimum of 6 hours per night. This is based on evidence that contractures did not occur in children with cerebral palsy when lower limb muscles were stretched for more than 6 hours (Tardieu et al., 1988). However, evidence that static splinting maintains the mechanical-elastic properties of muscle is weak (Pin et al., 2006), with support for this intervention coming from animal studies (Williams, 1988; Williams et al., 1988) and limited evidence in the adult lower limb literature (Light et al., 1984; Steffen and Mollinger, 1995). The optimal splint design or position is currently unknown. However, day splinting using neoprene and Lycra garments is not recommended, with limited evidence for their efficacy (Corn et al., 2003; Knox, 2003; Nicholson et al., 2001) and the potential to reduce antagonist muscle movement.

Casting is clinically indicated when fixed contractures are present. This achieves a low-load prolonged duration muscle stretch. Typically, a serial program is implemented whereby a cast is reapplied every 3 to 7 days, gradually increasing the passive range of movement across a joint until the desired range is achieved. Three to four serial casts will usually be adequate to achieve the desired range of movement, and static splinting following the casting program is recommended. However, due to a lack of evidence for the efficacy of casting in this setting (Lannin et al., 2007), decisions and casting protocols are based on clinical experience.

Activity Level: Occupational Therapy

It is generally recommended that occupational therapy should commence 2 to 4 weeks following injection, with research supporting intensive bursts of movement-based training provided once or twice weekly for 2 to 3 months following injection.

However, the optimal program of occupational therapy has not been established, and the following discussion concerns the emerging trends in therapy after injection of BoNT-A.

Traditional upper limb occupational therapy practice involves a bimanual approach to training that is underpinned by several theoretical models (Chapparo and Ranka, 1997; Kielhofner, 1995; Law et al., 1997). Occupational therapists target the treatment of hand skills with specific task practice using a motor skill acquisition frame of reference (Kaplan and Bedell, 1999). This approach is well supported by recent advances in knowledge in the areas of neuroscience, basic mechanisms of hand function, and, more specifically, motor control and motor learning theories (Eliasson, 2005).

The practical application of a movement-based paediatric occupational therapy program, targeting activity level outcomes, should include the *following principles* based on a motor skill acquisition frame of reference (Kaplan and Bedell, 1999):

- Task analysis to identify if performance is limited by execution of movement or motor planning difficulties (i.e., sequencing of movements) (Steenbergen and Gordon, 2006; Steenbergen et al., 2007).
- Repetitive whole task practice of challenging, motivating, and purposeful activities (i.e., toys and games), carefully selected to facilitate development of goal-based skills and independence with task completion.
- Use modeling, physical assistance, verbal cues, or environmental adaptation to enable the child to understand the critical features of the task and the environment.
- Facilitate the children's learning and understanding of the role of their assisting hand (i.e., hemiplegic assisting hand) using active problem solving.
- Grading of physical or verbal assistance provided to complete tasks.
- Provide feedback focusing on the movement outcome, task, and environment rather than on the specific movement performance.
- Provide opportunities for the child to practice tasks in a range of contexts and environments.

Charles and Gordon (2006) have recently presented a similar protocol described as *Hand-Arm Bimanual Intensive Training* (HABIT), in which intensive practice of bimanual tasks is undertaken over a 2-week period. In this protocol, however, the therapist does not handle the child to facilitate movement or assist in task completion, but environmental adaptation is used. Specific movements required for task completion are also practiced repetitively and intensively using a protocol similar to behavioral shaping (Morris and Taub, 2001).

Constraint-induced movement therapy (CIMT) (Taub, et al., 1999) (see Chapters 30 and 31) combined with botulinum Neurotoxin A injection can be effective in providing intensive practice to young children with hemiplegia who do not spontaneously use their affected upper limb or have a significant developmental disregard. As the emerging evidence is as supportive of modified CIT as it is of CIT (Hoare et al., 2007), a modified protocol using a mitt and 2 hours of daily practice for 2 months is suggested. A bimanual training program should follow shortly after.

Goal-directed programs for children over the age of 5 years are aimed at maximizing the learning and performance of skills required for school and daily life that need to be considered. Goal-directed training is an activity-based approach to therapy aiming to improve a person's ability to engage in meaningful activities (Mastos et al., 2007). Programs are implemented using principles of motor learning (Schmidt and Lee, 1999) and are based on four components: (1) selection of a meaningful goal, (2) analysis of baseline performance, (3) intervention/practice regime, and (4) evaluation of outcome (Mastos et al., 2007).

Prior to injection of botulinum Neurotoxin A, the Canadian Occupational Performance Measure (Law et al., 1994) and Goal Attainment Scaling (Kiresuk et al., 1994) can be used to identify a meaningful goal for a child. The therapist must observe the child's baseline performance of the task to identify the specific areas of limitation. This process facilitates treatment planning and may also assist in determining appropriate muscles to be targeted for injection with BoNT-A. Following injection, the occupational therapy intervention focuses on specific and repetitive practice of the chosen task. The role of the therapist is to create a learning situation to develop active problem solving, exploration of alternative strategies, and repetitive practice.

Evidence-Based Practice

There is a growing body of high-quality research supporting the efficacy of upper limb occupational therapy intervention in children with cerebral palsy. More recent trials (Boyd, 2004; Greaves, 2004; Lowe et al., 2006; Russo et al., 2007; Wallen et al., 2007) evaluating the effects of BoNT-A and occupational therapy with occupational therapy alone have demonstrated positive gains on activity level outcomes in both the treatment and control groups.

Goal-directed training has been shown to be effective in attainment of meaningful goals and improved self-care and mobility as measured by the Pediatric Evaluation of Disability Inventory (Ahl et al., 2005; Ketelaar et al., 2001).

Discussion

BoNT-A is used to reduce spasticity and dystonia in affected muscles. This offers a window of opportunity to effect impairment and activity-based treatment strategies that can assist the child in upper limb functioning. Although specific regimes of upper limb therapy require further rigorous scientific evaluation, therapy postinjection targeting functional tasks identified by goal setting is gaining evidence of efficacy.

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