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Therapeutic application of electrical stimulation and constraint induced movement therapy in perinatal brachial plexus injury: A case report

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ABSTRACT

Infants and children with perinatal brachial plexus injury (PBPI) have motion limitations in the shoulder, elbow, forearm and hand that are dependent on the level of injury and degree of recovery. The injury and subsequent recovery period occur during critical periods of central and spinal neural development placing infants and children at-risk for developmental disregard and disuse of the affected arm and hand. A case report outlines the therapy and surgical interventions provided in the first 2 years of life for a child with global PBPI and a positive Horner's sign. Electrical stimulation and constraint induced movement therapy provided sequentially were effective therapy interventions. Neurosurgery to repair the brachial plexus was performed at an optimal time period.[2] The Assisting Hand Assessment,[12] Modified Mallet[13] and Active Movement Scale[14] are effective outcome measures in PBPI and served as valuable guides for therapy intervention.

Oxford Level of Evidence: 3b; Individual Case Control Study.

Introduction

This retrospective case report outlines the therapy and surgical interventions provided in the first 2 years of life for a child with global (C5-T1) right perinatal brachial plexus injury (PBPI) and a positive Horner's sign. The incidence of PBPI ranges from 0.38 to 4.6 per 1000 live births.[1] Most infants (92%) show partial or full recovery in the first 3 months. Infants with global injury (flail arm) and a positive Horner's sign generally show no recovery by 3 months and carry a worse prognosis.[2] Our primary objective in this case was to determine if the application of electrical stimulation (ES) and constraint induced movement therapy (CIMT) would augment muscle activation and active movement in the affected arm and promote functional recovery. We propose that these targeted interventions along with appropriate surgical intervention, will benefit young infants and children with global PBPI who are at-risk for developmental disregard and subsequent motion and prehensile dysfunction.[3]

In animal models of PBPI the onset of fibrosis and muscle shortening can begin as early as 4 weeks in the denervated muscles.[4] Gentle stretching of the shoulder girdle muscles and the inferior scapula-humeral angle (ISHA) are important interventions to begin early and continue in order to prevent contracture. The effect of electrical stimulation (ES) on nerve regrowth is unclear.[5] Direct motor ES has been shown to increase muscle bulk. However, long pulsed (ms) durations can be uncomfortable and is controversial when used during nerve regeneration.[6] Some studies using short pulsed (μs) sensory ES after peripheral nerve injury have shown comparatively earlier functional recovery times.[7,8] We begin sensory ES on infants with PBPI as a home program as early as 6 weeks to optimize sensory activation of spared nerves in order to enhance cortical awareness. We stimulate the muscles that show loss of bulk.

Infants with PBPI may not be able to move their affected arm in a typical pattern or display isolated joint movement even when muscle recovery or reinnervation occurs. They often display muscle co-contraction and stiff movement. Reciprocal ES applied to opposing muscle groups primes the muscles and recreates the natural reciprocal pattern that occurs in early development. This form of motor ES has been shown to be effective in promoting reciprocal muscle activation and recovery of isolated movement in children with cerebral palsy (CP).[9] We have also found this approach to be clinically effective in children with PBPI (Fig. 1).

Constraint induced movement therapy (CIMT) has been shown to increase use of the affected arm in children with hemiplegic CP.[10]

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Fig. 1. Reciprocal ES for finger flexion and extension.

Case reports suggest it may also be useful to treat monoplegia and developmental disregard in PBPI.[11,12] The use of restraints on the unaffected arm of infants with PBPI in the form of socks or soft elbow extension splints promotes use of the affected arm when the infant decreases the integration of both hands. Following early restraining with CIMT casting or splinting at strategic intervals promotes visual attention and skill when combined with shaping activities for the affected arm.

The Assisting Hand Assessment (AHA),[13] Modified Mallet[14] and Active Movement Scale (AMS)[15] are frequently used outcome measures in PBPI. The AHA measures how well the affected hand is used in bimanual activity.[13] The Modified Mallet[14] and AMS[15] are measures of active motion. In this retrospective case, the AMS was used at periodic intervals starting 2 weeks after birth until age 2 (Fig. 2). The AHA and Modified Mallet were used every 2 months starting at 18 months (Table 1). These outcome measures were used to guide episodes of reciprocal ES, CIMT and bimanual training in order to determine their effectiveness and the necessity for different interventions.

Intervention

The timeline, sequence of interventions and outcomes in this retrospective case report of an infant with global right PBPI between 2 weeks and 2 years of age is depicted in Table 1. At 2 weeks PROM was initiated. At 6 weeks, a home program of sensory ES (100 μs pulse duration for optimal sub-motor threshold) was initiated. When motor recovery became apparent, sensory ES was stopped. Reciprocal ES (150 μs pulse duration with trace (1/5) level of contraction) was initiated at 11 months to promote efficient motor recruitment and isolated movement.[16] CIMT casting of the arm and hand was implemented 4 times to increase the use of the affected arm and focus on specific skill development.

Results

AMS Graph (Fig. 2) depicts changes in active movement over time. Scores below 4 indicate movement with gravity eliminated. Scores above 5 indicate movement against gravity.

The initial AMS score at 2 weeks indicated no movement throughout the arm and hand.

At 6 weeks there was a palpable contraction in the triceps. Neurosurgery occurred at 3 months. At 7 months (4 months post op) there were palpable contractions in the muscles of the shoulder, elbow and finger flexors. Movement against gravity emerged at 12 months in the elbow, 13 months in the fingers, 14 months in the shoulder, and 20 months in the wrist and thumb.

AHA and Modified Mallet (Table 1)

At 18 months, the child met the valid age criteria for the AHA and was able to perform the Modified Mallet. These outcome measures were used prior to CIMT casting and 4 weeks after CIMT casting. The AHA scores are reported as logit based 0 to 100 AHA units. An increase of 5 AHA units is significant.[17] There were significant increases in the AHA after CIMT casting episodes.

Modified Mallet scores were unchanged after the 19 day episode of CIMT casting but increased after the 5 week episode of CIMT casting.

Discussion

This case describes the therapy and surgical interventions in the first 2 years of life for a child with right global PBPI. Targeted interventions provided at specific time points had a positive effect. Early on, to augment muscle activation and prevent joint

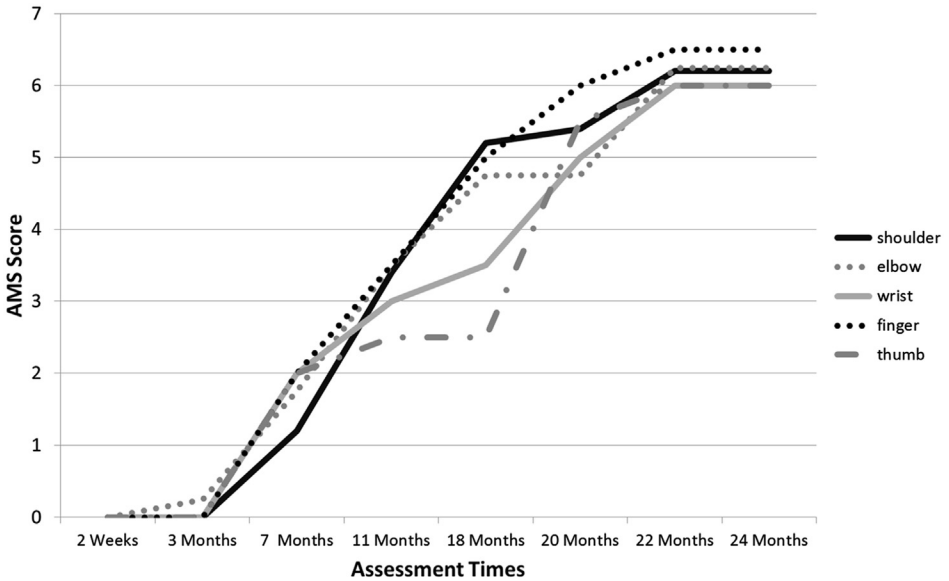

Fig. 2. Active movement scale.