**Obstetric Brachial Plexus Injury**

**Why does the impairment occur in this population?**

 The brachial plexus is a complex network of nerves originating from cervical (C5 to C8) and thoracic (T1) nerve roots. The nerve roots combine to form a series of trunks, divisions, cords, and branches that terminate in five peripheral nerves (axillary, musculocutaneous, median, radial and ulnar) controlling upper extremity movement and sensation. Other nerves of the brachial plexus originating more proximally to the spinal cord are the dorsal scapular, suprascapular and long thoracic nerves, which are important for shoulder girdle and upper extremity function; the phrenic nerve, which receives innervation from C5 and is involved in diaphragm function; and the preganglionic sympathetic fibers from the first thoracic root, which control a number of autonomic functions.4

 In the United States, the incidence of neonatal or obstetric brachial plexus injury (OBPI) is 1.5 per 1000 live births.9 Though controversial and multifactorial, the mechanism of injury in OBPI is thought to be associated with mechanical forces that occur during labor and delivery that stretch the brachial plexus beyond its resistance.1 Risk factors for OBPI include fetal macrosomia (birth weight over 4500 grams), instrumented delivery, prolonged labor, shoulder dystocia (a delay between the delivery of the neonates head and body secondary to shoulder obstruction), multi-parity, breech presentation, and gestational diabetes.4,9

**What are the manifestations/pathophysiology?**

 When the brachial plexus is stretched beyond its limits, a range of impairments may occur and affect upper extremity motor and sensory function. Obstetric brachial plexus injuries are classified according to three types of nerve fiber damage: neurapraxia, axonotmesis and neurotmesis. In neurapraxia, the nerve has been stretched causing a conduction block, but no axonal disruption has occurred, and the prognosis for full recovery is very good.4 With axonotmesis, the nerve has been compressed or has experienced traction.4 Recovery may be complete or incomplete and is dependent on myelin sheath disruption and axon damage.4 Neurotmesis involves the complete disruption of the nerve root either from a preganglionic avulsion or a post-ganglionic rupture. Without surgical intervention, there will be no recovery.4

 Historically, OBPI has been referred to as either Erb’s palsy, Klumpke’s palsy or Erb-Klumpke palsy. Erb’s palsy, which involves C5 and C6 nerve roots, is the most common type of OBPI followed by Erb-Klumpke palsy, which involves C5 through T1 nerves roots then Klumpke’s palsy, which involves C8 and T1 nerves roots.15More recently, OBPI has been classified according to four lesion levels. A Type I lesion, involves C5 and C6 nerve roots and is characterized by shoulder abduction and external rotation and elbow flexion weakness.15 Of note, the phrenic nerve receives contributions from C5 fibers and in some cases, diaphragm weakness occurs.15 In Type II lesions, C5, C6 and C7 nerve roots are involved, and the clinical presentation is similar to a Type I lesion, but wrist extension weakness is also be present.15 A Type III lesion involves C5, C6, C7, C8 and T1 nerve roots and is characterized by flaccid paralysis of the upper extremity.15 Type IV lesions are similar to Type III lesions; however, this lesion is complicated by sympathetic nerve fiber injury causing Horner syndrome which is characterized by ipsilateral ptosis, miosis and hemifacial anihidrosis.15

 Even in children with severe OBPI, sensory recovery has been reported to occur before motor recovery, and while full sensory recovery may not occur until age five, the prognosis for restored sensory function is very good.2 While assessment of sensory function may be more difficult in children, clinical manifestations of sensory impairment include injury, self-mutilation, and poor hand use.2Children with OBPI may also develop a form of learned nonuse called developmental disregard. Developmental disregard is a phenomenon seen in children born with sensory or motor impairments where affected extremity is disregarded and the non-involved extremity is used for daily activities.17 Given the potential for developmental disregard, its important for therapists to develop motivating and rewarding therapeutic activities that encourage use of the involved extremity.

**What does the literature suggest is effective to treat this impairment?**

 For most infants, OBPI resolves in the first three to four months of life and requires only conservative management with physical therapy*.*5,11The goal of physical therapy is to promote recovery of motor and sensory function and prevent muscle atrophy, developmental disregard, and secondary deformities.5,15If deltoid and bicep function have not returned by three months, primary reconstructive surgery may be indicated.8 Primary reconstruction involves exploration, evaluation and injury repair.8When the child’s progress has plateaued and functional deficits remain, secondary reconstructive surgery may be indicated.8 Secondary reconstruction involves muscle, tendon, or nerve transfers, joint fusion, or osteotomy.8Whether a child has surgery or not, physical therapy remains a part of OBPI management. Although literature evaluating the effectiveness of physical therapy interventions in OBPI management is limited, several studies were identified involving the following interventions: electrical stimulation, exercise and taping, constraint induced movement therapy (CIMT), botulinum toxin-A, and casting.

 When muscle is denervated, it undergoes structural and neurophysiological changes that result in atrophy.15Electrical stimulation to the injured nerve or denervated muscle has been recommended to increase muscle mass and counter atrophy, fibrosis and fat deposition;15 however, only one study has specifically investigated the effects of electrical stimulation in children with OBPI. Okafor et al. compared the effects of electrical stimulation to conventional physical therapy on arm function in children with Erb’s palsy.12 Sixteen children were randomly assigned to receive either electrical stimulation (ES) or conventional physical therapy (CPT) three days per week for six weeks. Outcomes included shoulder abduction, elbow flexion, and wrist extension range of motion and circumferential measures of the arm. Compared to the CPT group, the ES groups had significant improvements in all outcomes. While this study involved a comparison intervention, limitations were the small sample size and the lack of an outcome representing activity and/or participation.

 In a case report, Walsh examined the effects of Kinesio Taping and exercise on motor function in a two year old with an OBPI.19 The child had an inferior subluxation of the humeral head, a significant trumpet sign (a compensatory posture to hold the humerus in the socket), upper extremity asymmetry, scapular winging, decreased use of the involved arm, limited shoulder external rotation and forearm supination, and a Mallet score of 15/25 (the Mallet classification was developed to evaluate shoulder function in children with brachial plexus injuries). Kinesio Tape was applied to facilitate rotator cuff function and scapular stabilization. Average weekly wear time was four to five days per week for a total of 20 weeks. The physical therapist provided the child’s family with a play-based home exercise program; however, the author failed to include a clear description of the exercises. After the 20-week intervention period, the child displayed full range of motion, a Mallet score of 20/25, symmetrical upper extremity and shoulder girdle alignment, and increased functional use of the involved extremity. Since there was a significant improvement in humeral head position on X-ray, reconstructive surgery was cancelled. The parents continued taping for another four months. Six months after taping was discontinued, the author conducted a phone interview with the child’s parents who reported that gains had been maintained.

 In animal models, selected peripheral nerve injury has resulted in changes in spinal cord architecture.10 The changes occur in response to the injury and also in response to the recovery process.10 Furthermore, changes may be compensatory and supportive of function.10 For this reason, it is important to think about the contribution of the central nervous system in OBPI and consider interventions like CIMT to target problems like developmental disregard and take advantage of neural plasticity. In response to CIMT, children with hemiplegic cerebral palsy who had developmental disregard showed improvements in motor function.17 In 2010, Buesch et al. conducted the first published study involving CIMT and children with OBPI.7 The purpose of the study was to examine the feasibility of using a home-based CIMT program to improve upper extremity function in two 12 year-old males with upper OBPI. An A-B-A single case design was used. Intervention involved 126 hours of CIMT across three weeks for child A and 4.5 weeks for child B. It should be noted that one child continued routine physical therapy, which could have overestimated the effects of CIMT. Outcome was measured using the Melbourne Assessment of Unilateral Upper Limb Function (MA), the Nine-hole Peg Test (NHPT) and the Assisted Hand Assessment (AHA). While improvements were reported in MA and AHA scores, no changes were reported for the NHPT. Parent feedback indicated the intervention was “demanding and exhausting”. The authors concluded that controlled studies were warranted and intervention methods should be modified to be more motivating and feasible.

Citing the need for a more feasible CIMT approach,Vaz et al. examined the effects of a modified CIMT program on functional changes in a two-year old with Erb’s palsy.18 Based on functional limitations identified by the child’s mother, the therapist developed a schedule of three tasks to be practiced 30 minutes per day using the involved arm. The Toddler Arm Use Test (TAUT), a measure of functional use of the involved upper extremity, was administered pre-intervention and every two weeks during the 14-week intervention. Across the intervention period, improvements were reported in TAUT scores. Furthermore, the mother reported positive gains in the child’s performance of bimanual activities.

 Using the modified CIMT program developed by Vaz et al,18 Santamato et al. examined the effects of botulinum toxin type A (BTX-A) and modified CIMT in two children (females ages six and seven years) with upper OBPI.13 Intervention involved BTX-A injections to the involved biceps brachii and pectoralis muscles followed by daily muscle stretching exercises and elbow casting for 10 days. After cast removal, CIMT was initiated. Children participated in CIMT for 30 minutes per day for two months. From baseline to post-intervention the children experienced improvements on measures of muscle strength, ROM and function.

Basciani and Intiso investigated the effects of botulinum toxin type-A (BoNT-A) injection and plaster casting as an adjunct to physical therapy on muscle contracture, posture and function in children with mild Erb’s palsy.3 Twenty-two children ranging in age from two to nine years old participated. Neurological impairment and function were assessed at baseline, three, six and 12 months using goniometry (to measure elbow extension), the Medical Research Council scale, the Mallet scale, and the Nine-Hole Peg Test (NHPT). Intervention involved BoNT-A injections to the biceps brachii, brachialis, pronator teres and pectoralis major muscles followed by casting for 30 days. At 12-week intervals, for up to nine months, BoNT-A injections were repeated. During the BoNT-A intervention, the children participated in physical therapy involving proprioceptive neuromuscular facilitation (PNF) and stretching. At 12-month follow-up, significant improvements in active elbow extension and NHPT scores were reported, but MRC scale (a measure of muscle strength) and Mallet scores (a measure of function) were unchanged form baseline. The authors concluded that BoNT-A and casting were effective in reducing contracture, increasing elbow extension and improving function in children with mild Erb’s palsy.

 While the studies cited in this paper represent many of the common interventions used for OBPI, several methodological limitations were identified. Studies were characterized by small sample sizes that included mostly children with upper OBPI, which limit the studies’ power and generalizability to children with other types of OBPI. Furthermore, only one study involved a comparison intervention, and none of the studies involved a control group; therefore, causal relationships could not be established. With respect to outcomes, whether or not the therapist providing intervention was the therapist administering outcomes was not addressed, and rater bias may have been introduced. The studies cited represent a launching point for further research investigating the effects of physical therapy interventions on functional outcomes in children with OBPI.

**How does this information influence your treatment approach?**

What surprised me about the topic of OBPI is that most of the interventions I was using 12 years ago (exercise, CIMT, casting and splinting, electrical stimulation) are still used today; however, the evidence to support the interventions is lacking. In a paper reviewing the conservative management of OBPI, Bialocerkowski et al. highlighted that many of the studies to date have lacked a clear description of the intervention, have not included a theoretical basis to support the intervention, and have not used psychometrically sound outcome measures.6Furthermore, physicians have conducted many of the studies with little involvement from physical therapists in documenting and publishing the outcomes.6,11

 As I think about my treatment approach, I will be more aware of associated signs (torticollis, clavicular fracture), somatosensory deficits and sympathetic involvement (Horner’s syndrome) and be more diligent about using standardized measures to evaluate for change in function. With respect to measures, the Active Movement Scale, the Assisting Hand Assessment, the Pediatric Evaluation of Disability Inventory (PEDI), and the Pediatric Outcomes Data Collection Instrument (PODCI) have been reported to have strong psychometric properties and have been recommended to assess children with OBPI.6 Together, these measures represent domains of body function, activity and participation and are measures I will investigate further for use in the OBPI population. As children with OBPI age, I will think about not only their ability to adapt to impairments, but also how activity limitations (e.g. using both hands), participation restrictions (e.g. involvement in sports) and musculoskeletal pain have been reportedand how these problems may affect quality of life.14,16

 Constraint induced movement therapy appears to be a promising intervention. In the case of botulinum toxin type A injections, I might recommend casting as an adjunct. While I have used electrical stimulation with mixed results, evidence-based support for its use in OBPI is limited. If a child’s family and other healthcare providers feel that electrical stimulation could be beneficial and tolerated by the child, electrical stimulation should be considered. Until more conclusive evidence is available, searching the literature related to brachial plexus injury in adults, peripheral nerve injury in children or the intervention of interest in other pediatric populations might shore up support for a particular intervention. Combining this information with the child’s individual needs, my past experience, and expert opinion could guide me in selecting interventions that will lead to the most favorable outcomes.

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