Rehabilitation Program for Children With Brachial Plexus and Peripheral Nerve Injury

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An aggressive and integrated physical and occupational therapy program is essential in the treatment of congenital brachial plexus injuries and other severe upper extremity nerve injuries. This article addresses the evaluation, identification of needs, establishment of goals, and the approaches to rehabilitation treatment for patients with brachial plexus palsy and other peripheral nerve injuries. Rehabilitative therapy can preserve and build on gains made possible by medical or surgical interventions; however, therapy is vital to these children regardless of whether surgery is indicated. The therapist uses a problem-solving approach to evaluate the patient and select appropriate occupational and physical therapy treatment modalities. Therapy is continually adjusted based on each child's unique needs. An understanding of the therapy principles aids in making appropriate referrals and prescriptions, and helps to coordinate care between the therapist, pediatrician, neurologist, and surgeon.

THE THERAPIST'S initial evaluation of a patient with brachial plexus palsy or other major nerve injury includes a careful history including a psychosocial background. The physical examination should provide specific details about passive range of motion and active range of motion, strength of each muscle or muscle group, and sensibility of the involved upper extremity. The body posture should be evaluated, comparing the positioning of the head and the involved extremity in relation to the noninvolved extremity. The detailed therapist's evaluation augments the neurological database.

Passive range of motion refers to the distance that the examiner can move a joint without the patient feeling any restriction or any voluntary muscle contraction. This is assessed with goniometric measurements or as an estimated percentage of full range of motion. Patients with brachial plexus palsy often feel an abnormal tightness of the internal rotators of the shoulder. When evaluating for the possibility of tightness of the internal rotators it is important to stabilize the elbow at the side of the thorax. The elbow should be flexed at a 90° angle and the forearm kept in a neutral position. The maneuver to assess the range of shoulder rotation consists of gently moving the forearm externally by the wrist while maintaining the forearm in neutral position. The passive range of motion of the elbow, wrist, and finger joints should also be evaluated.

Active range of motion refers to the distance that a joint can move without any restriction by active muscle contraction. Active range of motion is measured with a goniometer or as a percentage of the range of motion of the normal side. The evaluation of active range of motion is difficult in children because of their lack of cooperation. An experienced therapist should be able to establish a relatively accurate measurement for each particular joint.

Strength is the ability of a muscle or muscle group to produce tension.[1] Manual muscle testing with reproducible data assists the clinician by establishing a quantitative baseline level of muscle strength against which recovery can be measured. Unfortunately, it is quite difficult to assess true muscle strength in neonates. Observing how the affected upper limb moves compared with the nonaffected limb, and evaluating neonate's ability to lift the affected arm against gravity or when gravity is eliminated can be helpful. It is important to provide stabilization of the proximal joint when testing the strength of a specific muscle or muscle groups. This avoids substitute motions. In the case of the biceps brachii muscle, for example, stabilization is achieved by holding the anterior shoulder with one hand while eliciting elbow flexion with the forearm in full supination. Additionally, the tension of the muscle, as determined by palpation during contraction, and the degree of movement should be considered when evaluating the strength of a muscle in a small child.

In fact, after the initial intensive therapy, parents are expected to carry out most of the exercises at

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home under the supervision of a therapist. They should be followed at regular intervals for reevaluation to monitor suppleness of joints and increasing strength and to upgrade home exercise programs. Joint physician-therapist evaluations every 3 months are useful. Parents must be encouraged to carry out home programs with their child. Older children are encouraged to participate in gross motor activities (ie, swimming, baseball, and other sports).

Finally, psychological support and psychotherapy can be helpful for families who have difficulties dealing with these difficult situations.

Sensory testing is especially difficult in infants. Formal sensory testing is impossible to accomplish in this age group, and therefore the therapist must rely on clinical observation and on information given by the parents or the caretakers during the interview with regard to absent or diminished protective sensibility. Findings should be recorded on a dermatomal chart.

Evaluation of body posture includes evaluation of a possible discrepancy between the limbs as well as head positioning and shape. Measurement of the length of the affected versus the nonaffected upper limb is part of the evaluation process of infants and children with brachial plexus palsy. Measurements of the limbs should be made at constant intervals to assess upper limb growth. Many children with brachial plexus palsy have difficulty turning their head to the affected side. This may be due to a shortened trapezius muscle caused by overuse and weakness of the sternocleidomastoid muscles. The combination of shortened trapezius and sternocleidomastoid muscle weakness can lead to torticollis and flattening of one side of the head, which can lead to permanent skull deformity (Fig 1). This acquired torticollis and skull asymmetry can often be prevented by properly positioning the child's head during sleep.

A video camera is an extremely useful tool in the evaluation of children with brachial plexus palsy and other paralytic problems. Sequential videotaping of the child from the initial evaluation throughout the treatment period is extremely important to document the changes that take place. Videotaping allows analysis of each movement multiple times to detect subtle changes. This dynamic documentation of the problem is important in planning appropriate treatment.

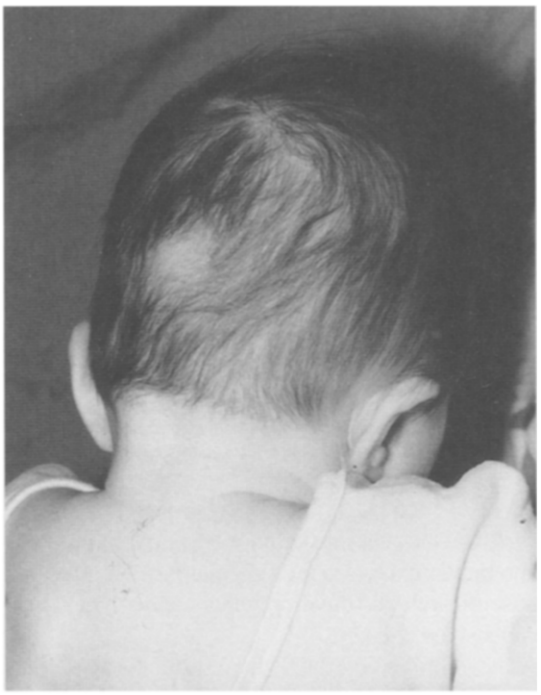

Fig 1. A child with a brachial plexus injury who has torticollis and obvious left skull deformity due to poor posturing and positioning.

OCCUPATIONAL AND PHYSICAL THERAPY

Management of patients with brachial plexus injuries requires an integration of basic physical and occupational therapy methods, preferably by a therapist who specializes in upper extremity rehabilitation. Routine orders should consist of providing active range of motion in the form of age-appropriate activities that encourage use of the weak extremity, passive range of motion, sensory education, and instructing parents on home exercise programs. The home exercise program should be updated on a regular basis.

There are several techniques based on the well-documented finding that certain body systems develop in response to the forces and stresses placed on them. Gravity is a constant force that affects the neuromuscular, musculoskeletal, and circulatory systems. Wolff's law states that growing bone adapts to the forces placed upon it.[2] In the developing human, gravitational stresses, particularly those that occur in weight-bearing positions, contribute to the growth of the skeletal system. Every normal muscular contraction also places a normal stress on bone and affects its shape and

Fig 2. It is important to encourage weight-bearing exercise to the impaired upper extremity to facilitate bone growth, even with marked weakness. Arrow points to involved limb.

density. Thus, the importance of performing these therapeutic exercises on a regular basis to promote musculoskeletal development cannot be overemphasized (Fig 2).

The mobility of the soft tissues, muscles, tendons, nerves, vessels, skin, fascia, and the joints is necessary for the performance of normal movements. When an individual with normal neuromuscular control carries out a functional task, the soft tissues continually elongate or shorten as joints move. If normal motion is restricted in any way due to muscle imbalance, shortening and tightness of soft tissues and joints will occur. This tightness causes pain and weakness and can lead to impaired mobility and ultimately to contracture. Contractures are an avoidable complication in children with nerve injuries. In the early stages of contracture development, mobility exercises must be used to restore full joint passive motion, thus preventing the occurrence of irreversible contractures. Neuromuscular electrical stimulation is a popular modality also used in the treatment of these children.

Proper joint kinematics maintain normal joint mobility. Capsular laxity allows for smooth, normal roll-gliding to occur between the bony surfaces within the joint.[3] Any restriction between joint surfaces will affect normal motion. Contractures, whether due to the soft tissue or joint surface problems, can often be avoided by mobility exercises. Mobility exercises include passive stretching, active stretching, flexibility exercises, and joint mobilization. In some cases, if the glenohumeral joint loses its congruency, normal gliding becomes impossible. Passive range of motion exercises become useless once a joint subluxes (Fig 3).

In children with a brachial palsy, the shoulder should be given special consideration as most of the muscles performing shoulder motions are attached to the scapula rather than the thorax. It is of utmost importance to stabilize the scapula when the shoulder girdle muscles are stretched. In children with brachial plexus injury, the groups of muscles most apt to demonstrate tightness are those that restrict shoulder flexion, abduction, and rotation, especially external rotation. There are a few individuals where one finds tightness in structures that prevent shoulder abduction and extension to neutral. Posterior dislocation or subluxation of the humeral head usually results from the imbalance of muscle forces around the shoulder and the posturing of the arm in adduction and internal rotation. It can manifest clinically by a posterior prominence and rounding of the shoulder and flattening of the anterior shoulder compared with the normal side combined with severe tightness in internal rotation. Motion is limited because the head of the humerus is fixed on the posterior rim of the humeral head. Pain is sometimes present during passive range of motion. The child increasingly postures in shoulder adduction and internal rotation. Surgical treatment is urgently required.

Postural education is an integral part of rehabilitation in children with brachial plexus palsy. As these children get older, they use specific compensatory maneuvers to be able to perform a movement. These compensatory movements may lead to aberrant postures. A sound rehabilitation program should introduce the correct movement pattern so as to recruit the specific muscle groups for a

Fig 3. Contractures lead to decreased active and passive range of motion and cause significant impairment in the function of the extremity. The extremity is fixed in internal rotation at the shoulder with the elbow held to the thorax. Passive external rotation is tested.

specific movement (Fig 4). This will also encourage good postural alignment. Failure to correct aberrant maneuvers often renders weak muscle groups that are not being used even though they are firing.

Winging of the scapula is a common phenomenon especially seen with older children who exhibit weakness of the rotator cuff muscles. This is one of the most difficult complications to address in terms of splinting. There are shoulder harnesses available commercially and some that can be made to fit the child. Usually older children choose not to wear them because they find these shoulder-scapula orthoses cumbersome. In younger children caretakers generally do not wish to make the child use it.

Myofascial release of the rhomboids, supra/infraspinatus, and teres major should be considered as part of the treatment regimen for shoulder problems. This technique is helpful in releasing fascial tissues that are restricting muscles and preventing normal scapula-humeral-thoracic rotation.[4] One should adhere to protocols and be cognizant of the contraindications in using this technique. A series of rotator cuff strengthening exercises, which can consist of active assist and active resistive exercises, is also helpful in addressing upper extremity proximal weakness even in young children (Fig 5). If resistance is applied to a muscle as it contracts, the muscle will become stronger over a period of time. Adaptive changes can occur in muscle through use of therapeutic exercise if the metabolic capabilities of the muscle are progressively overloaded.[5]

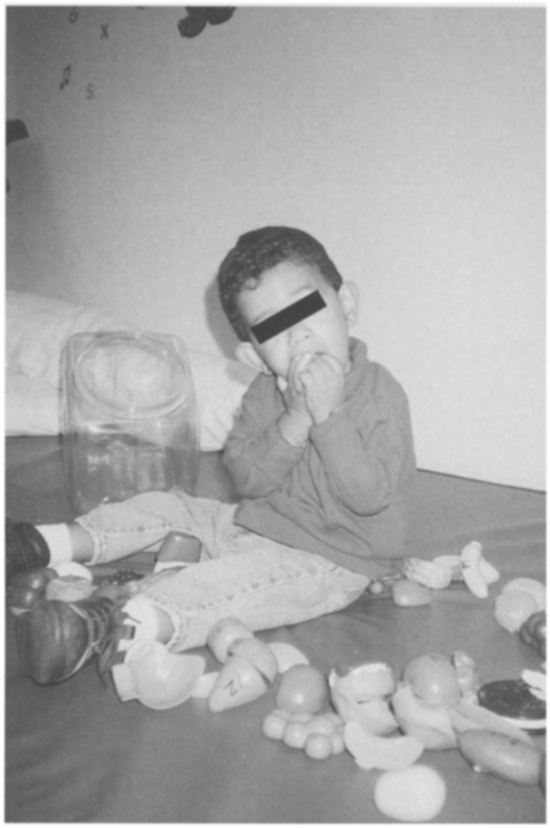

Fig 4. Children should be encouraged to use correct movement patterns and to decrease compensatory motions.

Fig 5. In older children, resistive exercises for the rotator cuff are useful.

When sensory deficits exist, sensory training may be included in the overall treatment approach. Even in young children, the use of sensory cues (tactile, visual, proprioceptive) to enhance motor performance should be seriously considered. Activities that promote joint proprioception should also be considered to develop sensory-motor potentials.

Use of splints is valuable and should be considered in cases where there is weakness, contracture, or to assist in preventing further deformity. There

Fig 6. Proper splints are especially helpful for children with wrist and finger weakness.

Fig 7. Proper electrode placements for application of neuromuscular electrical stimulation. Active electrodes on (A) deltoid and (B) wrist extensors.

are different types of orthoses that can be fabricated according to the needs of the child. Commercially available static and dynamic splints are useful depending on the problems that are identified (Fig 6). Proper splinting and casting requires close interaction between the physician and the therapist.

A home program for the parents or caregivers is an extremely important part of therapy. The home program may include passive range of motion, positioning and carrying techniques, age-appropriate activities to incorporate sensory stimulation, and weight bearing to the affected upper extremity. Passive range of motion should be performed consistently and regularly to promote suppleness of the joints. Positioning and carrying techniques should be reviewed to make sure that the affected extremity is always supported and protected whether the infant is supine, prone, or sitting.

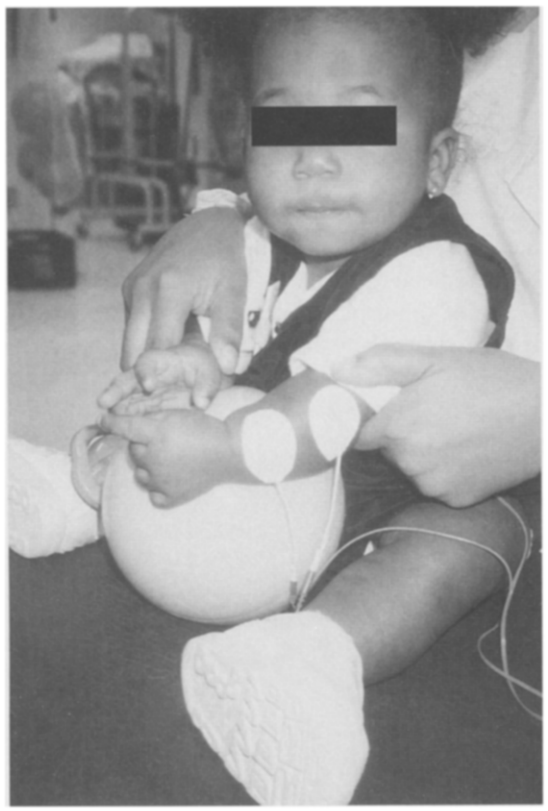

Fig 8. Neuromuscular electrical stimulation should be used in conjunction with a functional activity.

MODALITIES

Certain adjunct modalities have proven extremely useful in treating these children and should be considered when formulating a therapy plan. In ordering or using any type of treatment modality, it is imperative to have a basic understanding of the underlying principles and concepts that pertain to a specific modality. Indications and contraindications

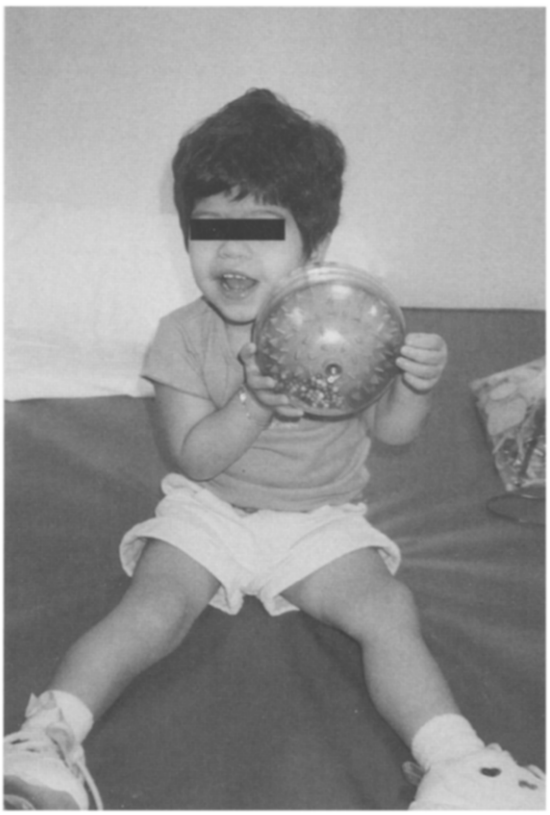

Fig 9. A child who underwent surgery at 4 months of age for a global injury to the brachial plexus. Patient is shown 18 months after surgery participating in a therapy program with bilateral activity encouraging use of the affected left upper extremity.

for each specific modality should be reviewed. Two of the most common modalities used in children with peripheral nerve injuries are heat and neuromuscular electrical stimulation (NMES).

Thermal modalities increase metabolic rate, promote circulation, provide needed nutrients to connective tissues, decrease pain, and tissue extensibility, which is a prerequisite for stretching tissue and passive range of motion. The use of thermal modalities must be closely monitored as children are more sensitive to heat and burns.

NMES is a general term describing a group of stimulators that use pulsating alternating current for stimulation of innervated musculature. Use of this type of stimulation has been reported to be beneficial for maintaining or gaining range of motion, facilitating muscle contraction, and alleviating the need for orthotic assistance (Fig 7 and 8).[6,7]

In neuromuscular electrical stimulation, knowledge of the physiological and electrical phenomena that transpire during the application of the electrical stimulation is crucial. Equally important is the understanding of the nerve and muscle excitation phenomenon.[8] Electrical stimulation is usually indicated when a person is unable to perform activities/exercises due to pain, restriction in range of motion, or other dysfunctions of the neuromuscular system.

The efficacy of neuromuscular electrical stimulation on injured nerve and denervated muscle has been questioned. Although there have been anecdotal reports as to the efficacy of its use, professional literature and data regarding NMES is still lacking for the treatment of brachial plexus and other major nerve injury. There is little literature available regarding the use of NMES in children. The most detailed reports are based on children with cerebral palsy.[9,10] Controversy exists among therapists as to whether or not this modality is appropriate for children who have a nonfunctional and insensate upper limb. Another controversy is timing of the use of neuromuscular electrical stimulation for an infant because there are no definitive data on the age to initiate this modality and the effect on regeneration of nerves.

In our experience, virtually every child with a peripheral nerve injury benefits at some point during rehabilitation from NMES. In each case, the parameters must be carefully adjusted to age and both the sensory and motor recovery. The benefits are most obvious when combined with a properly designed program of active and passive range of motion strengthening exercises and functional activities (Fig 9).

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