The Egyptian Journal of Hospital Medicine (October 2022) Vol. 89, Page 5561- 5566

Effect of Reciprocal Electrical Stimulation in Erb's Palsy Children

Emad R. Abdelaziz[1], Emam H Elnegmy[1], Amina Elhendawy[2], Amira E El-Bagalaty[1]
[1]Department of Physical Therapy for Pediatrics, Faculty of Physical Therapy, Cairo University, Giza, Egypt
[2]Department of Neuropediatrics, Faculty of Medicine, Cairo University, Giza, Egypt
***Corresponding author:** Emad R. Abdelaziz, **Mobile:** (+20) 01096664078, **E-Mail:** emadrashad500@gmail.com

ABSTRACT

Background: Erb's palsy is a disorder in which the upper section of the brachial plexus (C5, C6) that innervates the arm is destroyed, resulting in an adducted, internally rotated shoulder and a pronated forearm, commonly referred to as "waiter's tip position". The purpose of this study was to detect the effect of reciprocal electrical stimulation in Erb's palsy children. **Patients and methods:** A total of 30 Erb's palsy children of both sexes participated in this study with age ranging from 1 to 3 years; they were divided randomly into two groups of equal number (15 children in each group). *Group A r*eceived a specially designed physical therapy program only. *Group B* received the same specially designed physical therapy program given to group A in addition to reciprocal electrical stimulation for biceps and triceps muscles. Electroneurography technique was used for measuring the percentage of degeneration of the biceps brachii muscle. A computerized electromyography apparatus was used before and after treatment for both groups.

Results: There was improvement in functional recovery of the upper limb in Erb's palsy children of both groups, but in favor of *Group B.*

Conclusion: Reciprocal electrical stimulation has an effect on functional recovery of the upper limb in Erb's palsy children.

Keywords: Reciprocal electrical stimulation, Erb's palsy, brachial plexus, Physical therapy, Electroneurography technique.

INTRODUCTION

A newborn with obstetric brachial plexus injury (OBPI) has a peripheral nerve injury. It is frequently, but not always, associated with a traumatic birth injury and can result in long-term disability. Physicians who treat newborns should be familiar with the presenting symptoms, comorbid conditions, and prognostic factors. OBPI injuries have traditionally been labelled with the eponyms Erb's palsy or Klumpke palsy **(1).**

The continuation of the ventricular branches of the spinal nerves from C5 to T1, gives rise to seven terminal nerves and ten accessory branches, forming the brachial plexus. It usually receives a C4 ascending genus (prefixed plexus) and less often, a T2 ascending genus (suffix plexus). The upper trunk is made up of C5 and C6 nerve roots, the middle trunk is made up of only C7 nerve roots, and the lower trunk is made up of C8 and T1 nerve roots. Then each upper body divides into two anterior and posterior branches **(2).**

The most common type of obstetric brachial plexus injury (OBPI) affects the upper trunk root (C5, C6) (Erb's palsy), which can sometimes be associated with damage to the C7 root. The deltoid, biceps, biceps, coracobrachialis, and supraclavicular muscles all lose function in Erb's palsy, resulting in shoulder flattening and elbow flexion. Along with the loss of the C7 root there is also the loss of the wrist extension**(3).**

Motion limitation in the shoulder, elbow, forearm, and hand affect infants and children with obstetric brachial plexus injury (OBPI), depending on the severity of the injury and the extent of recovery. Because the injury and recovery period occur during important stages of central and spinal neuronal development, babies and children are at risk of developmental neglection and disuse of the affected arm and hand **(4).**

Arm paralysis, loss of muscle control in the arm, hand, or wrist, and loss of feeling or sensation in the arm are all possible outcomes. Although there are various causes for brachial plexus injuries, nerve compression or strain is the most prevalent cause. Infants, in particular, are susceptible to brachial plexus injuries during delivery, which manifest as specific patterns of weakness depending on which region of the brachial plexus is affected. Nerve root avulsion is the most serious type of injury, resulting in full paralysis of the associated muscles **(5).**

Excessive stretching of the plexus during delivery causes brachial plexus traction injuries. This is linked to either a difficult breech extraction, even in little newborns, or a cephalic presentation in a large child with shoulder dystocia **(6).**

Electrodiagnostic testing can help to confirm the diagnosis, locate lesions, determine the severity of axial discontinuity, and rule out other clinical possibilities. They are useful tools that should be used in conjunction with a thorough physical examination and proper imaging evaluation, not as a replacement for them **(7).**

In this investigation, electroneurography was chosen as a method of diagnosis and prognosis as **Sinclair (8)** confirmed that electrodiagnostic tests can help to determine the site (root and/or plexus), extent, and severity of a brachial plexus lesion. Motor nerve conduction tests including assessment of the amplitude of compound muscle action potential (CMAP) in distal and proximal muscles, provide useful prognostic information. These CMAP amplitudes can be compared to the intact side to see how much degeneration there are.

Received: 21/6/2022
Accepted: 29/8/2022

Nerve conduction abnormalities can predict certain pathologic processes like demyelination or axonal loss, as well as pinpoint the exact location of focal nerve lesions. In the nerve conduction studies, the conduction velocity, latency, and amplitude of reactions are all measured [(9)].

Stretching exercises, safe handling and early positioning skills, developmental and strengthening activities, and sensory awareness should all be included in a complete programme that should be established and updated as needed. Learning self-achievement specialized life skills is taught to older children with chronic disabilities [(10)].

When dealing with the unpleasant conditions of brachial plexus injuries, an effective occupational and physical treatment programme is essential. Preventing muscular atrophy until the nerves restore function is one of the key goals of rehabilitation. Electrical stimulation is a useful treatment for assisting patients in achieving this basic goal. Shoulder extension, flexion, depression, abduction, and adduction exercises promote healing by activating the nerves in the injured areas and improving muscular function. Daily stretching was done to improve or maintain range of motion [(11)].

Neuromuscular electrical stimulation (NMES) is a technique that includes applying electrical current to muscles in order to aid recovery after a nerve injury. A current is given to the affected muscle groups through a methodical selection of frequency, pulse duration, electrode placement, and amplitude, among other parameters. The settings, length of therapy, equipment, electrode placement, and adjunct therapies vary greatly [(12)]. The evidence for NMES's usefulness in treating peripheral nerve injury (especially severe or total injury) is mixed, in patients with obstetric brachial plexus palsy [(13)].

The purpose of this study was to detect the effect of reciprocal electrical stimulation in Erb's palsy children.

PATIENTS AND METHODS

Patients:

A total of 30 Erb's palsy children of both sexes participated in this study with age ranging from 1 to 3 years. All children were selected from the Out Patient Clinic, Faculty of Physical Therapy, Cairo University. They were divided randomly into two groups of equal number (15 children in each group). Subjects enrolled in the study with Erb's palsy children (C5, C6); all children had an axonotomesis degree of brachial plexus injury with grade 2 partial flexion on Gilbert- Raimondi Score for Elbow Function and muscle tone was hypotonic. Children with visual or hearing deficits and fixed deformities of the upper limbs or with surgical interference in the upper limb were excluded.

The children were allocated randomly into two equal groups. *Group A* received a specially designed physical therapy program only and *Group B* received the same specially designed physical therapy program used for *Group A,* in addition to reciprocal electrical stimulation for biceps and triceps muscles.

Randomization:

A total of 36 children were assessed for the eligibility criterion. Only 4 children were excluded as they did not meet the inclusion criteria, and 2 children were excluded as their parents refused to participate in the study. After we had taken the baseline measurements, the randomization process was applied by closed envelopes. The researchers prepared 15 closed envelopes labeled with a *Group A* and another 15 closed envelopes labeled with a *Group B*. Thereafter, we asked each parent to draw a closed envelope that contained one of the two groups.

Methods:

Pre-intervention evaluation:

Electroneurography technique (percentage of degeneration), a valid and objective method to record percentage of biceps nerve degeneration was assessed before and after the suggested period of treatment for both groups. We gave one orientation session for parents to be familiar with the equipment, the research team, and protocol.

Electroneurography technique:

For measuring the percentage of degeneration of the biceps brachii muscle, a computerized electromyography apparatus was used. To prepare the patient he/she was placed supine on an examination table, bare skin from waist up and the stimulating and the recording sites were cleaned with medical cotton damped with alcohol to reduce skin impedance. He/she was maintained in comfortable supine lying position.

Electroneurography was performed first for the sound side and then for the affected side. A bipolar stimulator was placed over the Erb’s point and manually adjusted to determine the best position to generate the compound muscle action potential (CMAP). For the biceps muscle, the active electrode was placed on the motor point of the biceps muscle also with the reference recording electrode placed farther distal on a relatively silent point **(fig. 1).**

Fig. (1): application of electroneurography.

Then on the affected side, the ground electrode was placed below the lateral 1/3 of the clavicle. The stimulation current intensity was increased stepwise until there was no further increase in the amplitude of the dysphasic myogenic cap.

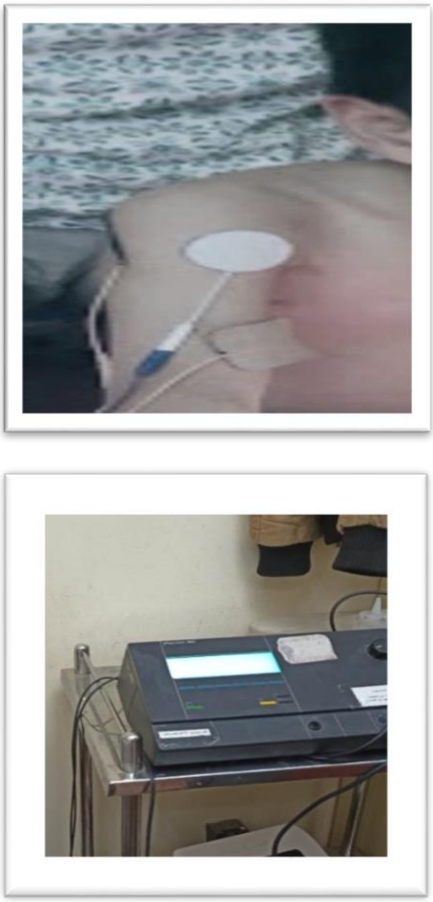
To calculate the percentage of degeneration the following equation

$$= 100 - \left(\frac{Amplituede\ of\ evoked\ response\ (in\ \mu V)\ Affected\ side}{Amplituede\ of\ evoked\ response\ (in\ \mu V) Normal\ side} \times 100\right)$$

Treatment sessions:

Group A received a specially designed physical therapy program**.** The frequency of exercises was three sessions per week for three successive months. The type of exercises included: Hand weight bearing exercises to improve proximal control, joint approximation technique to facilitate muscle tone and to stimulate the mechanoreceptors of the joints, tactile stimulation to facilitate muscle contraction, facilitation of hand function by reaching, grasping, manipulation and release in which motivational targets were used. Stretching exercises was done to maintain the length and elasticity of all soft tissues liable to be tight. Scapulo-thoracic mobilization and suckling exercise were done for infant aged 1 and 2 years.

Group B received the same specially designed physical therapy program given to *Group A* in addition to reciprocal electrical stimulation for biceps and triceps muscles with frequency of 30 Hz, pulse duration 1m/ sec, 10 second ramp up and 10 second ramp down alternatively for both muscle groups (biceps and triceps) for a total duration of 20 minutes[(14)] and the intensity was set as high as the child could tolerate and the intensity was increased during the intervention for the muscle to maintain sufficient and observable contraction[(15)]. The whole intervention was continued uninterrupted for 3 successive months (12 weeks), three sessions per week **(fig. 2 a, b).**



(a)

(b)

Fig. (2): reciprocal electrical stimulation on biceps and triceps muscles of the affected side.

Ethical consent:

The protocol was submitted to the Institutional Review Board of Cairo University, and ethical approval was obtained. The aims, purpose, and steps of the study were explained to the participant's parents. Also, the potential risks and benefits were explained to the parents. Parents provided an informed written consent form before starting the study. Parents of the children signed a consent form before participation. The Declaration of Helsinki and the ethics code of the world medical association for experiments for humans were followed.

Statistical analysis

The collected data were coded, processed and analyzed using the SPSS (Statistical Package for Social Sciences) version 25 for Windows® (IBM SPSS Inc, Chicago, IL, USA). The collected data of *Group A* and *Group B* were statistically analyzed to detect the effect of reciprocal electrical stimulation in Erb's palsy children. Descriptive statistics and unpaired t-test were conducted for comparison of the mean age between both groups. Chi squared test was conducted for comparison of sex distribution between both groups. Unpaired t test was conducted for comparison of pre and post treatment mean values of electroneurography (ENG) amplitude and percent of degeneration between both groups. Paired t test was conducted for comparison between pre and post treatment mean values of ENG amplitude and percent of degeneration in each group. The level of significance for all statistical tests was set at p <0.05.

RESULTS

Our results showed that there was no significant difference between the two groups at the baseline assessment (P-value >0.05). The comparing results of the percent of degeneration within groups were showed in **Tables 1, 2, 3 and 4**. The results of the mean values of the percent of degeneration of the pre and post physical therapy intervention appeared that there is a significant difference within groups as P value <0.05 **(Tables 1, 2, and 3).**

Table (1): Comparison between pretreatment mean values of percent of degeneration for both groups (A and B):

Groups	Percent of Degeneration (%) $\bar{X} \pm$ SD	MD	t-value	P-value	Sig
Group A	69.21 ± 2.32	0.46	0.39	0.69	NS
Group B	68.75 ± 3.94				

Table (2): Comparison between pre and post treatment mean values of percent of degeneration for group (A) and group (B):

Variable	Group A		Group B	
	Pre	Post	Pre	Post
Percent of degeneration (%) $\bar{X} \pm$ SD	69.21 ± 2.32	59.98 ± 2.5	68.75 ± 3.94	38.33 ± 8.23
MD	9.23		30.42	
% of change	13.33		44.24	
t-value	13.73		17.45	
p-value	0.0001		0.0001	
Sig	S		S	

Table (3): Comparison between post treatment mean values of percent of degeneration for both groups (A and B):

Group	Percent of degeneration (%) $\bar{X} \pm$ SD	MD	t-value	P-value	Sig
Group A	59.98 ± 2.5	21.65	9.74	0.0001	S
Group B	38.33 ± 8.23				

$\bar{X}$: Mean; MD: Mean difference; p-value: probability value; SD: standard deviation;
t-value: Unpaired t value; S: significant.

The statistical analysis of the mean difference between both groups was 21.65%. There was a significant decrease in post treatment mean value of the percent of degeneration of *Group B* compared with that of *Group A* (p = 0.0001) as shown in fig (3).

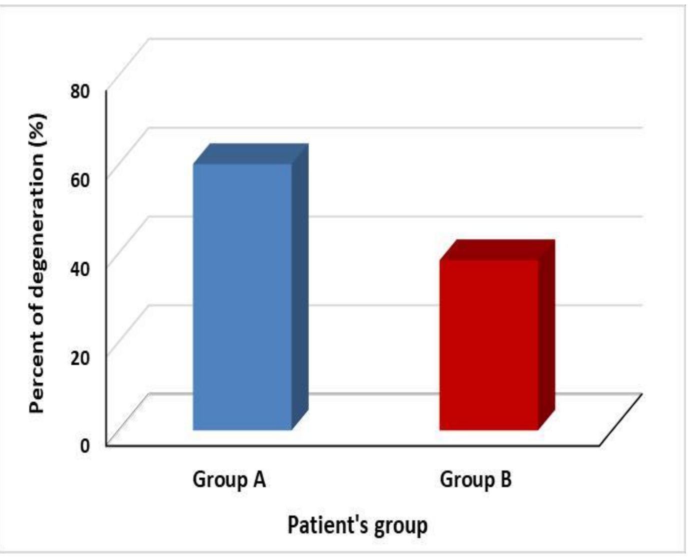


Fig. (3): Post treatment mean values of percentage of degeneration for both groups (A and B).

DISCUSSION

The findings of our study showed that the use of reciprocal electrical stimulation is relatively an effective method for improving muscle activity in children with Erb's palsy.

The electrical stimulation was applied to specific muscles of the upper limb which are the biceps muscle and the triceps muscle. This pattern of stimulation was selected, as it helps to facilitate elbow flexion and extension.

A total of 30 children suffering from Erb's palsy of both sexes were included in the present study with age ranged from one to three years. All children were selected from the Outpatient Clinic of the Faculty of Physical Therapy, Cairo University. They were divided randomly into two groups of equal numbers (15 children in each group). Control *Group A* was received a specially designed physical therapy program, and the study *Group B* received the same designed physical therapy program given to *Group A*, in addition to reciprocal electrical stimulation. Children in this study were assessed by ENG before and after the period of treatment (3 months) as ENG is one of the most objective, reliable and valid method used to detect denervation of the muscles. ENG is a test performed to evaluate and record the electrical activity produced by skeletal muscles **(16)**.

Electroneurography has been chosen as a method of diagnosis and prognosis in this study as **Squitieri *et al.*** **(7)**, confirmed that electrodiagnostic studies help the location (root and/or plexus), extent and severity of the brachial plexus injury. The researchers stated that motor nerve conduction studies with measurement of the amplitude of the CMAP in distal and proximal muscles provide useful prognostic information. These CMAP amplitudes may be compared to the intact side to establish a percentage of degeneration.

It is agreed with **Tsur and Ring** [17]**,** who said that Electroneurography can reveal decreased amplitude of the Sensorial and Motor potentials of the peripheral nerves. Decreased amplitude of the sensitive potential by 50% compared to the contralateral parameter can be considered diagnostic.

The study *Group B* who received electrical stimulation (ES) showed a significant difference than control *Group A*.

This come in line with **Elnaggar and Elbanna**[18]**,** who said that reciprocal electrical stimulation (RES) is a neuromuscular stimulation technique for alternate activation of agonist and antagonist muscle groups. The RES stimulation pattern can typically imitate the firing sequences of normal muscles and also improve neural drive through stimulation of sensory receptors and sensory neurons of agonist and antagonist muscles.

It also corresponds with the findings of **Brushart *et al.*** [19]**,** who found that ES enhanced axon outgrowth and crossing of the repair site. In both animal models and humans, greater axon outgrowth in response to ES results in earlier muscle reinnervation and functional recovery after both mixed and sensory nerve injury and surgical repair [20].

According to previous studies, reciprocal ES administered to the contralateral muscle area prepares the muscles and restores the natural reciprocal patterns that occur during early growth, **Berggren and Baker** [4] said, in children with cerebral palsy, this type of electromotor stimulation has been shown to be beneficial in producing mutual muscle activation and restoring isolated movements. This method is also used for children with OBPI; proven to be clinically useful. Neuromuscular electrical stimulation (NMES) is a technique that allows therapists to apply electrical current to a partially or completely denervated muscle in order to promote functional recovery. Erb described "degeneration syndrome" as early as 1868, in which a denervated muscle has a slow response to electrical stimulation, necessitating higher intensity and longer periods of stimulation for contraction [21].

The proportion of degeneration in the children treated with reciprocal electrical stimulation improved significantly and this come in agreement with **Badawy and Ibrahim** [22]**,** who said that the NMES has been shown to increase voluntary muscle activation and prevent muscular disuse atrophy in a variety of populations, including those with cerebral palsy. The most likely explanation is that NMES has the same effect as voluntary muscle contraction in temporarily increasing muscle metabolism and blood flow, facilitating more spinal motor neuron pools, and stimulating blood flow to atrophied muscles to deliver growth factors and nutrients necessary to improve muscle structure and function. NMES is thought to deliver proprioceptive input to muscles, allowing them to contract and increase activity. As a result, more muscle fibers are engaged and contracted as NMES continues.

In conclusion, from the obtained results of this study, it may be concluded that reciprocal electrical stimulation has an effect on functional recovery of the upper limb in Erb's palsy children.

Financial support and sponsorship: Nil.
Conflict of interest: Nil.

REFERENCES

1. **Sutcliffe T (2007):** Brachial plexus injury in the newborn. Neo Reviews, 8:239-246.
2. **Abid A (2016):** Brachial plexus birth palsy: Management during the first year of life. Orthopaedics & Traumatology: Surgery & Research, 102:125-132.
3. **Ali Z, Dara B, Li Y *et al.* (2014):** Utility of delayed surgical repair of neonatal brachial plexus Palsy. J Neurosurg Pediatrics, 13:462-470.
4. **Berggren J, Baker L (2015):** Therapeutic application of electrical stimulation and constraint induced movement therapy in perinatal brachial plexus injury: A case report. Journal of Hand Therapy, 28(2):217-221.
5. **Hems, T, Mahmood, F (2012):** Injuries of the terminal branches of the infraclavicular brachial plexus: patterns of injury, management and outcome. The Journal of Bone and Joint Surgery, 94(6):799-804.
6. **Fujak A, Kopschina C, Gras F *et al.* (2010):** Contractures of the upper extremities in spinal muscular atrophy type II. Descriptive clinical study with retrospective data collection. Ortho Traumatol Rehabil., 12(5):410-419.
7. **Squitieri L, Larson B, Chang K *et al.* (2013):** Medical decision-making among adolescents with neonatal brachial plexus palsy and their families: a qualitative study". Plast Reconstr Surg., 131:880-887.
8. **Sinclair C, Murray P, Terkonda S (2008):** Combined intrauterine vascular insufficiency and brachial plexus palsy: a case report. Hand (N Y), 3(2):135-138.
9. **Ahn S, Yoon B, Kim J *et al.* (2018):** Nerve conduction studies: basic principal and clinical usefulness. Annals of Clinical Neurophysiology, 20(2):71-78.
10. **Michaud L, Louden E, Lippert W *et al.* (2014):** Use of botulinum toxin type A in the management of neonatal brachial plexus palsy. PM & R., 6(12):1107-1119.
11. **Nath R, Karicherla P, Mahmooduddin F (2010):** Shoulder function and anatomy in complete obstetric brachial plexus palsy: long-term improvement after triangle tilt surgery. Child's Nervous System, 26(8):1009-1019.
12. **Adedeji G, Oyelese O (2009):** Conservative management of bilateral obstetric brachial plexus palsy: A case report. Physiotherapy Singapore, 13(2):27-31.
13. **Somashekar D, Di Pietro M, Joseph J *et al.* (2016):** Utility of ultrasound in noninvasive preoperative workup of neonatal brachial plexus palsy. Pediatric Radiology, 46(5):695-703.
14. **Postans N, Granat M (2005):** Effect of functional electrical stimulation, applied during walking, on gait in spastic cerebral palsy. Developmental Medicine and Child Neurology, 47(1):46-52.

15. **Khalili M, Hajihassanie A (2008):** Electrical simulation in addition to passive stretch has a small effect on spasticity and contracture in children with cerebral palsy: a randomised within-participant controlled trial. Australian Journal of Physiotherapy, 54(3):185-189.
16. **Haig A, Yamakawa K, Kendall R *et al.* (2006):** Assessment of the validity of masking in electrodiagnostic research. American Journal of Physical Medicine & Rehabilitation, 85(6):475-481.
17. **Tsur A, Ring H (2008):** Axillary nerve conduction changes in hemiplegia. Journal of Brachial Plexus and Peripheral Nerve Injury, 3:26. doi: 10.1186/1749-7221-3-26
18. **Elnaggar R, Elbanna M (2009):** Evaluation of independent versus integrated effects of reciprocal electrical stimulation and botulinum toxin-A on dynamic limits of postural stability and ankle kinematics in spastic diplegia: a single-blinded randomized trial. European Journal of Physical and Rehabilitation Medicine, 55(2):241-249.
19. **Brushart T, Hoffman P, Royall R *et al.* (2002):** Electrical stimulation promotes motorneuron regeneration without increasing its speed or conditioning the neuron. J Neurosci., 22(15): 6631-6638.
20. **Wong J, Olson J, Morhart M *et al.* (2015):** Electrical stimulation enhances sensory recovery: a randomized controlled trial. Ann Neurol., 77:996-1006.
21. **Cummings J (1985):** Conservative management of peripheral nerve injuries utilizing selective electrical stimulation of denervated muscle with exponentially progressive current forms. The Journal of Orthopaedic and Sports Physical Therapy, 7(1):11-15.
22. **Badawy W, Ibrahim M (2015):** Balance training versus reciprocal electrical stimulation on knee joint alignment in spastic diplegic cerebral palsy children. Bulletin of Faculty of Physical Therapy, 20(2):146-153. Doi:10.4103/1110-6611.174694.