ORIGINAL RESEARCH PAPER

Physiotherapy

NEUROPLASTICITY, A BOON IN THE MANAGEMENT OF TRAUMATIC BRACHIAL PLEXUS INJURY AFTER NERVE TRANSFER: A NARRATIVE REVIEW.

KEY WORDS: nerve transfers, neuroplasticity, rehabilitation, traumatic brachial plexus injury

Chhaya Verma* M.Sc (Physical Therapy in Hand Rehabilitation), PGDHHM (Hospital Health Care Management), Professor & Head, Physiotherapy School and Centre, TNMC and BYL Nair Hospital, Mumbai Central, Mumbai 400 008. *Corresponding Author

Raveena Kini MPT Musculoskeletal Physiotherapy,Physiotherapy School and Centre, Seth GS Medical College and KEM Hospital,Parel, Mumbai 400012.

Sujata Yardi M.Sc (Physical Therapy), PGDR, Ex-Director & Professor, School of Physiotherapy, DY Patil University, Nerul, Navi Mumbai.

Vinita Puri MS (Gen.Surg), MCh (Plastic Surgery), Professor and Head, Department of Plastic & Reconstructive Surgery, Seth GS Medical college and KEM Hospital, Parel, Mumbai 400012.

ABSTRACT

Purpose of article: To build a comprehensive narrative review that highlights the effects of neuroplasticity in the rehabilitation after a surgical nerve transfer in an acquired peripheral nervous system condition such as traumatic brachial plexus injury.

Materials and Methods: The review involves searches of various electronic databases and materials from the year 2008 to 2018, published in English. The key words used were nerve transfers, neuroplasticity, rehabilitation, and traumatic brachial plexus injury. After thorough reviewing the relevant articles were short listed.

Results and Conclusion: 16 articles got shortlisted. There is considerable evidence that the brain possesses the ability to recognize and incorporate new information even after a peripheral lesion followed by its surgical reconstruction. Various studies identify the different rehabilitation strategies that could help enhance this virtue of neuroplasticity thereby positively maximizing the outcome.

INTRODUCTION

Brachial plexus injuries are of different types. Normally they are classified as partial or complete (global) based on the level and extent of lesion and the residual disability in the patient. Another classification based on the affection of the nerves with respect to the dorsal root ganglion involves a pre ganglionic or a post ganglionic injury. [1] In the pre ganglionic injury there may be signs of autonomic nervous system affection giving rise to sensory symptoms, though the sensory nerve action potential may be normal unlike in a post ganglionic injury. [2]

Studies done by Goldie et al (1992) and Midha et al (1997) already stated an increase in occurrence of brachial plexus injury as a part of multitrauma admissions due to two wheeler accidents in United Kingdom and Canada respectively. [3,4] Furthermore, adding to the literature, a recent epidemiological study conducted in an Indian centre by Jain et al (2012) states a 30% increase in the incidence of brachial plexus injury in the Indian population. [5]

Given an overall increase in the statistics of its occurrence, it becomes necessary to probe into ways of treating and rehabilitating the cases of traumatic brachial plexus injury.

Brachial plexus injuries which show no spontaneous recovery are usually explored. [1] Now early nerve transfers or neurotization techniques are quite rampant among surgeons as a primary choice for treatment post injury if the patient fulfils the criteria's of a nerve transfer as it has good outcomes. [1,6]

Speaking of the surgical and rehabilitation aspects of traumatic brachial plexus injury, neuroplasticity tends to play a very important role. It is actually the structural reorganization that takes place in the cortex and is used synonymously to cortical mapping. [7] The cortical homunculus is basically the physical representation of each part of the human body in the brain. Studies have shown that brain plasticity infact is one of the important principles to allow the central nervous system to adapt and modify its structural organization and function in response to a functional demand, internal or external. [8,9] Yoshikawa et al in their study based on longitudinal functional MRI study suggest that the sensorimotor cortex contralateral to affected is activated lesser at approximately three months after injury and the activation is minimized even further at the end of a year thereby supporting the changes in the brain post a peripheral injury.[10] A recent case study under taken by Dimou et al showed that post a brachial plexus transfer to the contralateral side, area of cortex contralateral to the reinnervated arm becomes active in addition to ipsilateral cortical activation suggesting functional reorganization in the brain post the transfer.[11]

Thus the present study aims to review literature available to highlight the effects of neuroplasticity in the rehabilitation of an acquired peripheral nervous system related condition such as traumatic brachial plexus injury patients thereby positively maximizing the outcomes of the rehabilitation.

METHODOLOGY

The review involves searches of electronic databases including Cochrane, PEDro, Google Scholar and PubMed and reference to books from the year 2008 to 2018. The key words used were nerve transfers, neuroplasticity, rehabilitation and traumatic brachial plexus injury. 22 articles where found out of which 16 got shortlisted. The inclusion criteria were the articles and book references that included traumatic brachial plexus injury management specific to nerve transfers working mainly on the neuroplasticity. The articles not involving neuroplasticity based rehabilitation were excluded from the study. The review includes 5 case studies, 3 observational Studies, 4 review articles, 1 randomized control trial, 1 commentary, and 2 book reviews.

DISCUSSION

A study done by Jacobs and Donoghue suggest that when the brain's motor and somatosensory homunculi are deprived of afferent stimuli from the affected side, reorganization occurs in the adjacent areas supplying intact structures thereby increasing their area demarcated within the cortex via an alterations in current connections. [12]

Similarly, the neuronal restoration done by surgical procedures are directly or indirectly helped by the process of neuroplasticity. The invasion of deafferentiated areas by the nerves that are supplying the adjacent areas occurs, the very principle behind nerve transfers for such injuries and insults. The distance between the cortical areas of the donor and the recipient neurons, presence of interneuronal connections, brain trauma, age and rehabilitation

are considered while planning for nerve transfers as these factors are related to the cortical plasticity [13]

Normally nerve transfers are of two types viz intraplexal and extra plexal. Intra plexal involves median nerve and ulnar nerve transfers (Oberlin procedures) to musculocutaneous nerve or nerve to biceps in order to obtain the functional elbow flexion or Somsaks technique where the nerve to triceps is given to the axillary nerve. It is based on the on the fact distance which the outgrowing axon has to cross is short. The transfer is performed distally with lesser distance to cover leading to faster muscle reinnervation. In addition, successful distal transfers illustrate the two core principles of neuroplasticity that determine good results: 1) the donor and recipient regions of the cortex belong to the same motor control pathways and 2) prior connections between the two areas exist. [1,9]

Likewise extraplexal nerve transfers involves spinal accessory nerve transfer to suprascapular nerve to obtain shoulder abduction and external rotation and intercostal nerve or phrenic nerve transfer to musculocutaneous nerve to obtain functional elbow flexion. The initial elbow flexion activity here is controlled by the sagittal region of the primary motor cortex related to active respiration by intercostal nerves. Slowly the area of cortical activation is shifted from medial to lateral (which is the original area of biceps activity).[1,14] Similar effects are seen in phrenic nerve transfers which is initially movement with breathing control followed by breathing independent as the person is rehabilitated. Studies have shown a very successful reinnervation of biceps post this transfer which means there has to be a presence of a common input response between corticospinal neurons of the intercostal nerve donor and the musculocutaneous nerve acceptor to obtain a satisfactory outcome post transfer. [9]

Another surgical aspect involves contralateral C7 transfers from healthy arm. Functional MRI over the same case suggests bilateral activation of cortex in the movement of the reinnervated arm. [15]
Successful treatment of traumatic brachial plexus injury not only stops at a successful surgery but ends with a successful rehabilitation program with patient compliance being the epitome of the cause of good, successful outcomes. Similar to the surgical aspect of treating traumatic brachial plexus injury, physical therapy and rehabilitation also run on the lines of cortical plasticity.

Modulating central nervous system responses to peripheral nerve injuries is a common part of the current rehabilitation strategies. Learned non-use could be overcome by restricting the use of unaffected extremity for several days, thereby training the use of the deafferented extremity. [16] This is also supported by Smania et al, where they recommends using constraint induced movement therapy for the treatment of both obstretic as well as adult brachial plexus injury. [17]

Physiotherapists are supposed to start with induction exercises or donor activation focused rehabilitation approach (DAFRA), as proposed by Kahn et al, to maximize outcomes post nerve transfers as soon as the patient is referred (3 weeks post operative). [18] It is a motor relearning and retraining program which emphasizes on the strengthening of altered neural pathways. It requires the therapist to be well versed with the anatomical aspects of the surgery. There needs to be the contraction of muscle from the donor nerve in order to activate the muscle from the recipient nerve. Initially till the first contraction in the muscle of the recipient nerve is received, it is always activated with the contraction of the muscle of the donor nerve. Once it is achieved, progressive strengthening of the recipient is done with dissociation of movement to achieve a more controlled contraction from the target muscle using either electromyography or using visual and auditory biofeedback. A literature review by Beers et al suggests that DAFRA in upper trunk injuries got the strength back to grade 4 and 5 after thorough follow up of the patients. [19] Dahlin et al in their study suggests that voluntary elbow flexion has been obtained by transfer using cortical plasticity by initially using the coughing and deep breathing function of the intercostal and phrenic nerve. [20] Infact studies suggest that there are reorganizational changes occur in the patients cortical diaphragm areas leading to independent control of breathing and elbow flexion with the same set of neurons as dissociation proceeds. [21]

Another concept usually followed simultaneously with DAFRA is the use of cross over therapy wherein there is emphasis of contraction of the muscle of the contralateral unaffected side to facilitate relearning on the affected side. This again is based on fact there is learning due to cortical connections and Sherringtons law of irradiation. [22]

A novice technique in the rehabilitation of brachial plexus injury is Graded Motor Imagery. Though this technique was first applicable only on patients with central nervous system affection, Susan Stralka et al (2016) refers to the occurrence of cortical neuroplasticity even in peripheral nerve injury patients.[23] Thereby it refers to the use of graded motor imagery even among peripheral nerve injuries, brachial plexus injuries being one of them. It has three steps, viz implicit motor imagery, explicit motor imagery and mirror therapy. Mirror therapy has proven to be useful in treatment of neuropathic pain, which is common in patients with traumatic brachial plexus injury, thereby adding to the evidence. [24] A pilot study done by Struma et al suggests rehabilitation of brachial plexus injury following nerve transfers occurs best in three phases. Phase 1 involves motor imagery and mirror therapy which enhances cortical activation, phase 2 includes activation of reinnervated muscle and phase 3 involves relearning original movement with training of activities of daily living. This has suggested better recovery of patients than those following conventional physiotherapy. [25]

Adding to the above, electrotherapeutic currents have always been an adjunct to the mainstream treatment. Interrupted galvanic stimulation is used when the power of the muscle is zero as it aids in regeneration of nerves. When the power is progressed from zero to one, faradic re-education is started. It depends on the fact that the brain understands movement not muscle and passive contraction of the muscle with the help of currents produces movements which helps the brain remember and learn. Okafar et al in his study concludes that electrical stimulation is preferred to conventional approach for early resolution of Erbs palsy. [26] In a study conducted by by Novak et al electrical stimulation is a good source to improve the axonal regeneration, however when the reinnervated fibres are not sufficient electrical stimulation will help to produce contraction by spreading to the adjacent uninjured muscle. They also state that electrical stimulation needs to be used as an adjunct with patients efforts as a sensory and motor stimulus for relearning. [27]

CONCLUSION AND CLINICAL APPLICATION

There is considerable evidence that the brain possesses the ability to recognize and incorporate new information even after a peripheral lesion followed by its surgical reconstruction. Neuroplasticity allows the central nervous system of the affected individual to adapt to both internal and external stimuli. Traumatic brachial plexus injury is one such extremely devastating peripheral condition where we require tremendous amount of patience, cooperation and teamwork among the surgeons, therapists, medical social workers and psychiatrists or psychologists with utmost compliance from patients. Therapists should know the anatomical aspects of neurotization surgery and must use the boon of neuroplasticity after the nerve transfer to help the patient get back to the functional levels and as closer as possible to near normal.

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