Post nerve transfer neuroplastic motor retraining program in adults with traumatic brachial plexus injury: A physiotherapist's perspective

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Abstract
Traumatic Brachial Plexus Injury is a devastating, acquired peripheral nerve injury seldom due to road traffic accidents, involving young males, especially riding two wheelers. Recent epidemiological studies undertaken in Indian population suggest a 30% increase in the occurrence of traumatic brachial plexus injury over the years. There has been an advent of a lot of new surgical techniques for the treatment of traumatic brachial plexus injury, nerve transfers being one of them if the patient falls within the criteria's of carrying out a nerve transfer. As a physiotherapist rehabilitating these surgical procedures, one needs to have a thorough understanding of the anatomical aspects of the surgery and how to go about the rehabilitation of the same. Thus the aim of this narrative report is to discuss the rehabilitation techniques followed over a decade at a government tertiary care hospital leading to successful rehabilitation of traumatic brachial plexus injury patients.

Keywords: Nerve transfers, Rehabilitation, Traumatic brachial plexus injury.

Introduction
Traumatic Brachial Plexus Injury is a devastating, acquired peripheral nerve injury seldom due to road traffic accidents, involving young males, especially riding two wheelers.[1,2] There are different levels of brachial plexus injury viz upper trunk injury (involving C5-C6 or C5-C7 roots as shown in Fig. 2a), lower trunk injury (involving C8-T1 roots as shown in Fig. 2b) and global or PAN brachial plexus injury (involving C5-T1 roots).[1] Recent epidemiological studies undertaken in Indian population suggest a 30% increase in the occurrence of traumatic brachial plexus injury over the years.[2-4]

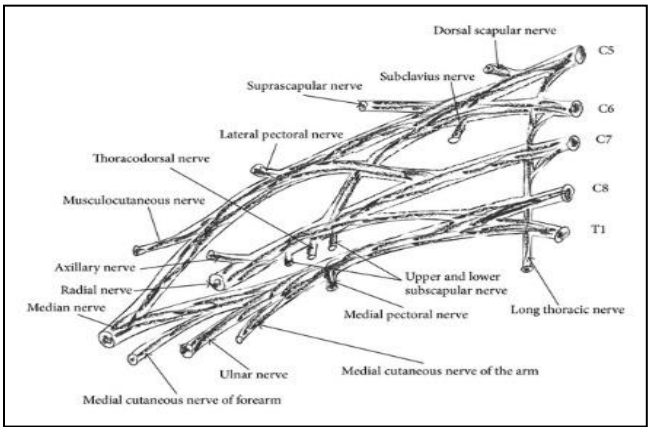

Fig. 1: Normal Brachial Plexus Anatomy (Courtesy: Sakellariou V et al, 2014. Retrieved from https://www.hindawi.com/journals/isrn/2014/726103/)

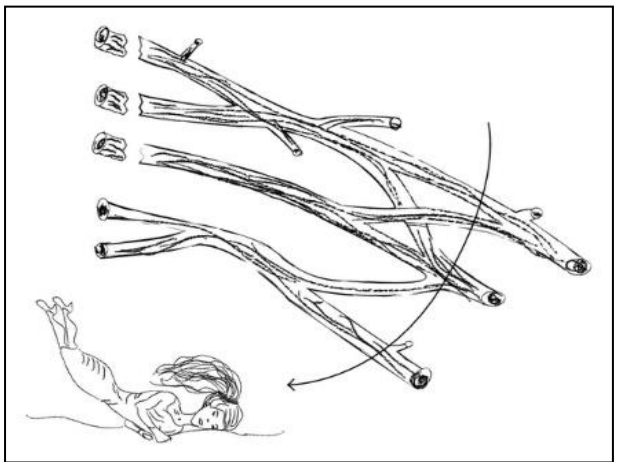

Fig. 2a: Upper plexus injury due to traction forces

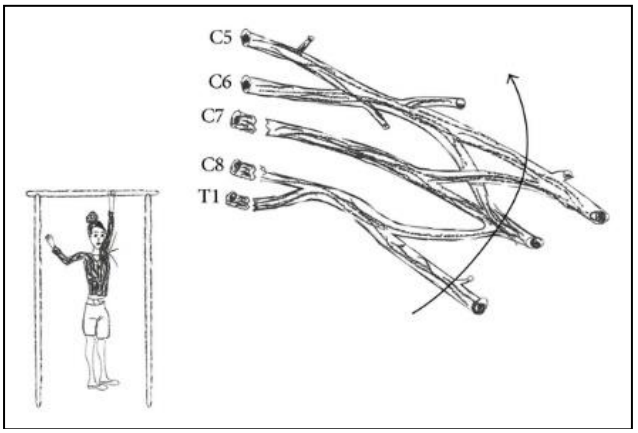

Fig. 2b: Lower plexus injury due to hyperabduction (Courtesy: Sakellariou V et al, 2014. Retrieved from https://www.hindawi.com/journals/isrn/2014/726103/)

Nerve transfers, rampantly used by reconstructive surgeons as a treatment strategy especially with superior results in upper plexus injury,[5] works on the principle of neuroplasticity. It involves invasion of the deafferented areas with the nerves innervating the adjacent area.[6]

Nerve transfer, also referred to as neurotisation technique, is a redirection or transfer of a viable and intact motor nerve from a muscle situation near the affected area that has sustained irreparable proximal damage, and co-apting it to a distal portion of the nerve there by crossing the affected portion of the nerve.[7,8] So there is a donor nerve (eg Ulnar Nerve) and a recipient nerve (eg Musculocutaneous Nerve) as shown in Fig. 3.

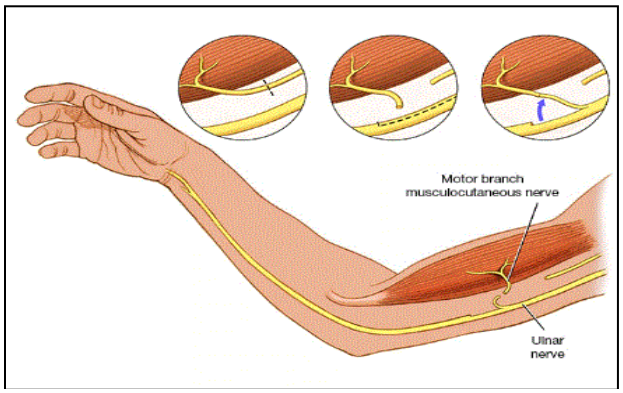

Fig. 3: Ulnar nerve transfer to motor branch of musculocutaneous nerve (Oberlin's transfer) (Courtesy: Mayo Clinic. Retrieved from https://www.mayoclinic.org/diseases-conditions/brachial-plexus-injury/multimedia/nerve-transfer/img-20008552 [Accessed 8 May 2019])

Aim

There has been an advent of a lot of new surgical techniques for the treatment of traumatic brachial plexus injury, nerve transfers being one of them if the patient falls within the criteria's of carrying out a nerve transfer. As a physiotherapist rehabilitating these surgical procedures, one needs to have a thorough understanding of the anatomical aspects of the surgery and how to go about the rehabilitation of the same. Thus the aim of the narrative report is to discuss the rehabilitation techniques followed over a decade at a foremost academic, government tertiary care hospital from Mumbai leading to successful rehabilitation of traumatic brachial plexus injury patients.

Discussion

Pre-surgery rehabilitation

Prior to the nerve transfer a physiotherapist must assess the level of lesion clinically and correlate with electro-diagnostic and electro-physiologic tests[9] to ascertain the level of lesion and the degree of injury. The motor and sensory assessment of the affected upper extremity must be done along with comparison to the unaffected side. Muscle strength assessment is done using British Medical Research Council grading.[10]

Table 1: British medical research council grading of muscles.[10]

0–No contraction
1- Flicker or trace of contraction
2 - Active movement, with gravity eliminated
3 - Active movement against gravity
4 - Active movement against gravity and resistance
5 - Normal power

The findings must also be discussed with reconstructive surgeon to make sure there is a holistic approach and consensus in managing the patients. The physiotherapist must understand the anatomical aspects of the surgery in order to understand that the muscles supplied by the donor nerve needs to be strengthened in order to reduce the chances of the residual weakness in the muscles of donor nerve post the transfer. This deals with the changes in body structure and body function aspect of International Classification of Functioning, Disability and Health along with understanding the patients present Activity Limitation and Participation Restriction as shown in Fig. 4.[11] Other clinical joint specific objective measures taken for brachial plexus injuries are Naraka's score for shoulder function,[12] the Waikakul's score for elbow function[13] and Raimondi's score for wrist and hand function.[14]

Along with assessing the patient with regards to the Body Functions and Structure component of International Classification of Functioning, Disability and Health, probing into the details of the contextual factors, quality of life and current functioning of the patient is essential as those factors also have a widespread impact on the recovery of the patient post the surgery. Subjective outcome measures must be taken like Disability Arm Shoulder Hand (DASH) which is a 30 itemed patient reported outcome measure with good reliability and validity.[15] Quality of Life Questionnaires also need to be taken which include 36 itemed questionnaire SF-36[16] and 26 itemed World Health Organization-Quality of Life BREF having good reliability and validity[17] to compare the difference post the surgery and optimum period of rehabilitation as patient satisfaction also is equally important as much as clinical improvement.

Patient education is a very integral part of the management during which therapist should come at par with patients understanding of the condition and their expectation from the surgery and rehabilitation. It includes imparting them with the knowledge of the importance of physiotherapeutic motor relearning program and educating them about the significance of their long term compliance in the treatment plan.[18]

Post-surgery Rehabilitation

After a successful nerve transfer, the patient is immobilized in a sling as shown in Fig. 5, for about 4-6weeks based on surgeon's discretion.

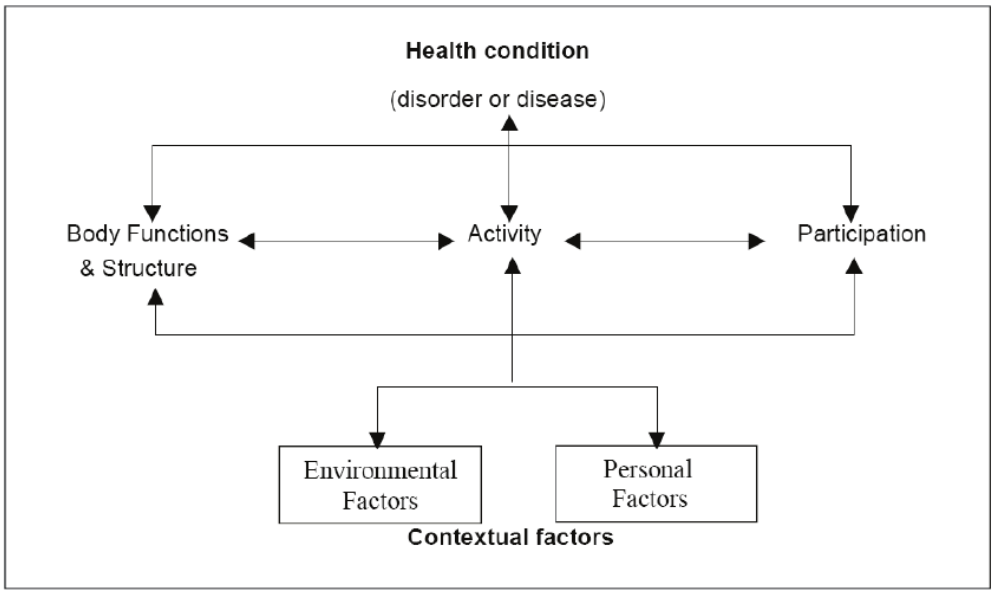

Fig. 4: ICF model demonstrating the bidirectional model and the various factors leading to the health condition. (Courtesy: World Health Organization, 2002. Retrieved from https://www.who.int/classifications/icf/icfbeginnersguide.pdf)

Fig. 5: Image of Traumatic Brachial Plexus injury patient without and with sling.

Nerve transfers are usually extraplexal, where the nerves are transferred from outside the plexus (eg.cranial nerve like spinal accessory nerve to suprascapular nerve and intercostal nerve to musculocutaneous nerve) or intraplexal where the nerves are transferred from within the plexus in case of partial brachial plexus injury (eg.Oberlin's transfer of ulnar or median nerve fascicle to musculocutaneous nerve).[1]

Initially we aim for the initiation of muscle contraction. Induction exercises are begun which are also referred to by Kahn et al as Donor Activation Focused Rehabilitation Approach (DAFRA)which are based on the anatomical aspects of the surgery.[19] Here the action of the muscle from the donor nerve is achieved prior in order to induce the action in the muscle of the recipient nerve. Just to give an example, when a fascicle of spinal accessory nerve supplying upper trapezius is transferred to the suprascapular nerve supplying supraspinatus, the training begins with simultaneous abduction and external rotation of glenohumeral joint along with elevation of the shoulder girdle and tucking of humeral head. We begin with a range of 45^{o} of abduction passively for the first week of

rehabilitation (after the requisite 4-6 weeks of immobilization period) and slowly progress to 10° abduction range every week. Some examples of Induction Exercises are shown in Table 2 and 3.

Table 2: Induction exercises for nerve transfers done to obtain Shoulder function.[1]

Surgery Done	Recipient Action	Donor Action
1. Spinal Accessory Nerve to Suprascapular Nerve	Shoulder Abduction & External Rotation	Shoulder girdle elevation
2. Radial Nerve of Triceps to Axillary Nerve (Somsak's technique)	Shoulder Abduction	Elbow Extension

Table 3: Induction exercises for nerve transfers done to obtain Elbow function.[1]

Surgery Done	Recipient Action	Donor action
1. Intercostal Nerve to Nerve to biceps	Elbow flexion	Active inspiration/ chest expansion exercises
2. Median Nerve fascicle to Nerve to biceps (Oberlin 2)	Elbow flexion	Wrist flexion/ Fisting
3. Ulnar Nerve Fascicle to Nerve to biceps (Oberlin 1)	Elbow flexion	Flexion and ulnar deviation of wrist
4. Contralateral C7 transfers	Elbow flexion	Contralateral elbow extension

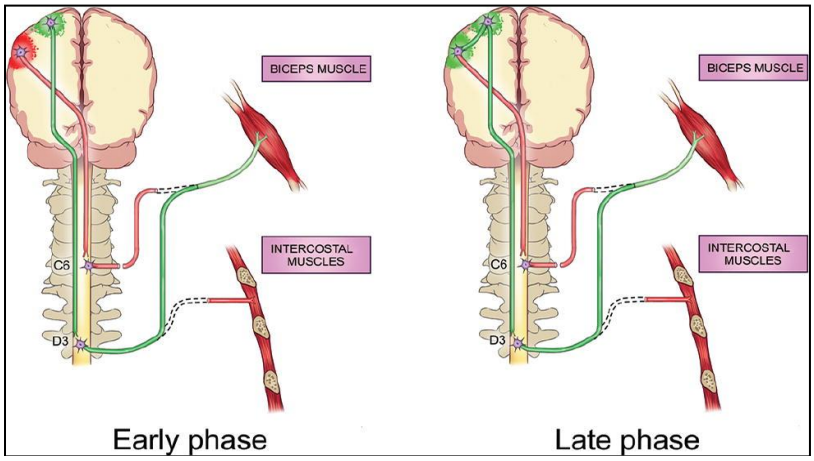

Fig. 8: Cortical plasticity post Intercostal Nerve to Nerve to biceps (Musculocutaneous nerve)(Courtesy: Socolovsky M et al, 2014 Retrieved from https://thejns.org/focus/view/journals/neurosurg-focus/42/3/article-pE13.xml)

Cross over therapy is done simultaneously, where in there is emphasis of contraction of the muscle of the contralateral unaffected side to facilitate relearning on the affected side. Studies have shown that it works through irradiation based on Sherrington's concept.[20, 21]

Graded motor imagery is a novice concept which has gained momentum in the recent years in the management of adult traumatic brachial plexus injury. It has three steps which includes implicit motor imagery involving right- left discrimination, followed by explicit motor imagery involving imagination of movements without actually performing them after which finally there is mirror therapy where the patients are asked to see the movement of the unaffected extremity on the mirror behind which the affected extremity is kept just for the patient to imagine that the movement is coming from the affected extremity, by activating the pool of the mirror neurons in the brain.[22] Struma et al suggests that graded motor imagery tends to facilitate cortical activation and therefore assist in bringing about neuroplastic changes in the brain through re-training. [23]

Neuro muscular electrical stimulation is used simultaneously, with electrodes placed over the muscle of the recipient nerve. It helps not only in producing a contraction of muscle of recipient nerve but also facilitates the growth and assists in the axonal regeneration of the affected recipient nerve.[24]When the muscle power is zero, a long duration interrupted galvanic current is used to bring about muscle contraction which is coordinated with contraction of donor muscle. When the muscle power progresses to one, a short duration faradic current is used. So we proceed from long pulse to short pulse gradually as muscle starts getting innervated. To give an example, when the intercostal nerve transfer is done to musculocutaneous

nerve (nerve to biceps), the initial muscle strength of biceps is zero. The electrodes are placed over the biceps. When the interrupted galvanic current produces the contraction in biceps, simultaneously the patient is asked to do the action of intercostal nerve which is deep breathing or chest expansion exercise, thereby following the method of induction exercises here as well.

Once the flicker is achieved in the muscle of the recipient nerve, slowly the dissociation of movements using Electromyography or Biofeedback is proceeded to, and a more controlled recipient contraction is the focus. Once a flicker is attained muscle is trained in the gravity eliminated plane to achieve a muscle power of grade 2. After grade 2 muscle strength is achieved, further strengthening is done using the rabands and weights.

Clinical Implication

The article implies to educate the therapists regarding the management protocol of Adult Traumatic Brachial Plexus Injury patients which has been designed and enhanced at foremost academic, government tertiary care hospital from Mumbai over a decade. The techniques used are hassle free and do not require extensive machinery hence convenient even for an average physiotherapy department. Studies have shown that individually these techniques have a successful outcome in the management of traumatic brachial plexus injury. Thus a strategic and systematic combination of all these techniques not only would deliver successful rehabilitation outcomes post nerve transfers but also help improve patient's quality of life.

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