



Clinical and Functional Evaluation of Nerve Transfer in Patients with Traumatic Brachial Plexus Injury

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Abstract

Background : Traumatic Brachial Plexus Injury (TBPI) is an injury to the peripheral nerves in the neck and shoulder area, which lead to the paralysis of the shoulder, elbow, wrist, and fingers muscles. The previous investigation showed that TBPI affects various aspects of a patient's life such as the permanent loss of function in daily activities and work. The reconstruction of the nerve on the brachial plexus is to restore clinical function and achieve optimal quality of life. Therefore, this study aims to evaluate the relationship between the time to surgery and the clinical as well as the functional outcomes of patients with TBPI after nerve transfer surgery. **Case** : An analytical observational study with a retrospective cohort design was conducted. The data were taken from all TBPI patients who had passed through nerve transfer surgery by a surgeon (HSO) at the Soetomo General Academic Hospital between January 2009 and December 2019. After meeting the inclusion and exclusion criteria, pre- and postoperative data DASH, VAS, SF36, shoulder range of motion (ROM), elbow and wrist ROM, as well as the sensory function of sample patients were recorded and tabulated. The data obtained were analyzed for distribution normality and the significance was tested using a T-test or Mann Whitney. **Result** : A total of 50 TBPI patients who are mostly adults (n=25, 50%), male (n=45, 90%) was evaluated. Based on the comparison between pre- and post-operative scores in patients who were operated on <6 months versus >6 months after injury, significant improvements were discovered in <6 months operation on almost all metrics. These include DASH, VAS, SF36, Shoulder Strength and ROM, Elbow strength and ROM, as well as wrist strength and ROM, except for sensory values, namely <6 months and >6 month with hypoesthesia which were 66.67%, and 73.7%, respectively, with p=0.23. **Conclusion**: Shorter delay between injury and surgery in TBPI patients improved pain outcome, quality of life, and arm function

Key Words: Brachial Plexus Injury, Nerve Transfer, Clinical Evaluation

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Introduction

Traumatic Brachial Plexus Injury (TBPI) is an injury to the peripheral nerves in the neck and shoulder area that causes the paralysis of the

shoulder, elbow, wrist, and fingers muscles. A peripheral nerve in the neck area formed by the 5, 6, 7, 8, and 1 thoracal cervical nerve roots can be damaged by overstretching, compression, or exposure to sharp objects (Suroto, 2019).

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Based on previous epidemiological studies in America and Europe, approximately 10-20% of peripheral nerve injuries are brachial plexus, where 80-90% are caused by motor accidents. These injuries are mostly found in the age range of 15-25 years (Smania, 2012).

Several epidemiological studies were also conducted between 2005 and 2017 at the Department of Orthopedics and Traumatology, Soetomo General Academic Hospital. It was discovered that 423 patients had surgery on brachial plexus lesions, where most mechanisms were 90% motorcycle accidents, 3% bicycle, and 3% home accidents (Suroto, 2019).

The objective of nerve reconstruction in the brachial is to restore clinical function and achieve optimal quality of life. Moreover, the result of the procedure depends on the extent of the lesion and the remaining function such as elbow flexion which is the priority of therapy, followed by the restoration of the shoulder and hand (Bhandari, 2016).

Successful nerve transfer in brachial plexus lesions is usually followed by clinical and functional outcome assessment as a postoperative follow-up. This study aims to evaluate the relationship between the time to surgery and the clinical as well as the functional outcomes of patients with TBPI after nerve transfer surgery.

Case

An analytical observational study with a retrospective cohort design was conducted on 50 post-neural transfer surgery patients with TBPI. This was carried out by a single operator from January 2009 to January 2019.

Sample and Population

Patients with TBPI who had nerve transfer surgery and met the inclusion criteria were used as a sample. The sample calculation formula shows that 8 samples were required for each group, so a minimum of 16 samples should be expected in total. The consecutive sampling technique was used, where each patient who met the inclusion and exclusion criteria would be included in the study sample until the required numbers are achieved.

Inclusion and Exclusion Criteria

The inclusion criteria of this study were participants within productive age (17 to 65 years), had nerve transfer surgery which was performed by HSO, and consent to participate.

Meanwhile, the exclusion criteria were patients with Obstetrical Brachial Plexus Palsy (OBPP) lesions, comorbidities at risk for polyneuropathy, and unconscious or organic brain injury.

Study Variable

The independent variables were patients who had nerve transfer surgery after TBPI. The dependent variables were functional scoring outcome (DASH score system, VAS, and SF 36) and clinical evaluation, which include range of motion (ROM), sensory and motor function.

Time and Place of Study

This study was conducted at the Orthopedic & Traumatology Outpatient ward, Soetomo General Academic Hospital from August 1 to December 30, 2020.

Study Procedure

For preparation, initial data were collected from the medical record database to identify patients with TBPI between January 2009 to December 2019. Based on the existing secondary data, the initial value of clinical and functional scores were recorded. Meanwhile, patients were firstly asked for their consent to participate in this study and re-interviewed for the evaluation of post-operative conditions.

The data that have been collected are tested for distribution normality. When the result is normal, the significance test was carried out using a t-test. Meanwhile, when the data distribution is not normal, it is followed up with a non-parametric Mann-Whitney test. The existing data were processed using SPSS version 16.0 (SPSS Inc, Chicago, Illinois, USA).

Ethical Clearance

This study has met the ethical requirements and obtained Good Clinical Practice certification for its implementation.

Results and Discussion

The sample was divided into 2 categories, where the interval from injury to surgery was < 6 months and > 6 months in groups 1 and 2, respectively. Each sample was evaluated on the comparison of the difference between pre- and post-operative values of the function, pain, quality of life, and patient satisfaction. This was based on an evaluation method that assessed shoulder muscle strength and ROM, elbow muscle strength and ROM, wrist muscle strength and ROM, as well as VAS and DASH scores.

Table 1. Demographic data of samples

No	Characteristic	<6 Months (%)	>6 Months (%)
1	Age		
	Teenagers	5 (10%)	14 (28%)
	Adult	4 (8%)	21 (42%)
	Elderly	3 (6%)	3 (6%)
2	Gender		
	Male	11 (22%)	34 (68%)
	Female	1 (2%)	4 (8%)
3	Affected side		
	Right	3 (6%)	28 (56%)
	Left	9 (18%)	10 (20%)
	Right & Left	0 (0)	0 (0)
4	Body Mass Index		
	Underweight	0 (0%)	0 (0%)
	Normal	4 (8%)	11 (22%)
	Overweight	4 (8%)	9 (18%)
	Obese	4 (8%)	18 (36%)

5	Level of Nerve Lesion		
	C5-C6	5 (10%)	21 (42%)
	C5-C6-C7	7 (14%)	17 (34%)
	C5-Th1	0 (0%)	0 (0%)
6	Other lesion		
	Other lesion exists	3 (6%)	3 (6%)
	No other lesion exists	9 (18%)	35 (70%)
7	Mode of Injury		
	Traffic Accidents	11 (22%)	37 (74%)
	Work related Accidents	1 (2%)	0 (0%)
	Fall from height	0 (0%)	1 (2%)
	Sport Injury	0 (0%)	0 (0%)

The comparison of the difference between pre- and post-operative scores was carried out using Mann Whitney because most of the distributions were not normal. The summary of normality and significance tests is presented in Table 2.

Table 2. Normality test and statistical differences in preoperative and postoperative values on various assessment metrics

	Functional Score	Time to Surgery	N	Percentage	Average	SD	Normality Test	P-Value
Score difference between preoperative and postoperative	DASH	<6 Months	12	24	30.32	5.57	0.42	0.04*
		>6 Months	38	76	20.75	14.9	0.81	
	VAS	<6 Months	12	24	2.92	0.29	0*	0*^
		>6 Months	38	76	1.82	0.83	0*	
	SF36	<6 Months	12	24	29.79	12.83	0.824	0.01*
		>6 Months	38	76	37.88	5.49	0.729	
	Shoulder Muscle Strength	<6 Months	12	24	2	0.6	0.01*	0*^
		>6 Months	38	76	0.79	0.96	0*	
	Shoulder ROM	<6 Months	12	24	53.33	30.92	0*	0.01*^
		>6 Months	38	76	30.79	37.17	0*	
	Elbow Muscle Strength	<6 Months	12	24	1.67	0.89	0.16	0.01*^
		>6 Months	38	76	0.74	0.95	0*	
	Elbow ROM	<6 Months	12	24	47.92	14.53	0.04*	0.01*^
		>6 Months	38	76	23.82	27.37	0*	
	Wrist Muscle Strength	<6 Months	12	24	1.75	0.5	0*	0*^
		>6 Months	38	76	0.75	0.6	0.01*	
	Wrist ROM	<6 Months	12	24	35.83	5.57	0.01*	0*^
		>6 Months	38	76	16.31	15.71	0*	

* Significant difference; Not normal distribution on the normality test

^ Tested using Mann-Whitney



The difference between DASH scores was 30.32 ± 5.57 and 20.75 ± 14.9 , respectively. Since the distribution test was normal, the data were tested using an independent T-test. The results showed a significant difference in functional outcomes between the group with time to surgery of <6 months compared to >6 months ($p = 0.04$).

The comparison between VAS values in TBPI patients with different times of surgery was carried out using the Mann-Whitney non-parametric test because the data distribution was not normal. Based on the results, the difference in values were 2.92 ± 0.29 and 1.82 ± 0.83 , respectively, while the statistical tests gave a significant difference of $p < 0.05$.

The comparison to the SF36 values was 29.79 ± 12.83 and 37.02 ± 7.7 with a normal distribution and the independent t-test discovered a significant difference ($p=0.00$). These results indicate a better functional outcome in the group with time to surgery of <6 months compared to >6 months.

Both the muscle strength and shoulder ROM also have abnormal distribution. The tests using Mann-Whitney showed significant differences between groups Shoulder strength and ROM in <6 months compared to >6 months are 2 ± 0.6 and 0.79 ± 0.96 with $p = 0.00$, as well as 53.33 ± 30.92 and 30.79 ± 37.17 with $p=0.01$, respectively. Since the elbow ROM data also showed abnormal distribution, a Mann Whitney was carried out. The results showed significant differences between groups, where elbow muscle strength and ROM in <6 months compared to >6 months are 1.67 ± 0.89 and 0.74 ± 0.95 with $p = 0.01$ as well as 47.92 ± 14.53 and 23.82 ± 27.37 with $p=0.01$, respectively. Similarly, there was an abnormal distribution for wrist data, and the Mann-Whitney test showed a significant difference, where the Wrist muscle strength and ROM in <6 months compared to >6 months was 1.75 ± 0.75 and 0.5 ± 0.6 with $p = 0.00$, as well as 35.83 ± 5.57 and 16.31 ± 15.71 with $p=0.00$, respectively.

Based on detailed sensory values as shown in Table 3, it is discovered that the percentage of the <6 months group that has normal sensory is 66.67%, while the >6 months group also has 75%. This indicates that the two groups tend to show normal sensory results. According to the Fisher's Exact Test analysis in Table 18, there are no significant differences between the sensory mean of each group ($p=1.000$). This shows that

the functional outcomes were significantly different based on the postoperative sensory scores of patients with brachial plexus lesions in the two groups, respectively.

Table 3. Analysis of Fisher's Exact Test on sensory scores between groups

	Time to Surgery	Normal		Hypoesthesia		p-Value
		n	%	n	%	
Sensorics	<6 Months	4	33.3%	8	66.7%	0.23
	>6 Months	10	26.3%	28	73.7	

Compressed nerves usually occur due to the continuous effect of the structures that had passed through the fibrosis and atrophy process. This reduces the hope for recovery, and it was also assumed that paralysis cannot be recovered (Tavakkolizadeh, Saifuddin and Birch, 2001; Grinsell and Keating, 2014, Suroto, 2019). This paralysis significantly affects the psycho-socio-economic aspects of patients, where there is an increase in the incidence of post-traumatic stress disorder (4.87%), major depression (24.4%), anxiety (4.87%), risk of suicide (7.3%), and psychotic disorders (2.43%) (Suroto et al., 2020).

Most of TBPI patients in this study were adults (50%) with 90% male, however, the lesion was also discovered in children. This is in line with the investigation by Smania, where male patients were 89% at risk of developing brachial plexus lesions (Smania et al., 2012). It was also reported that the prevalence in the United States is 0.64-3.9/100,000 patients/year (Kaiser, 2020).

In this study, the motor scores on the shoulder ($p=0.000$), elbow ($p=0.003$), and wrist ($p=0.000$) in the >6 months group were significantly different. There were also significantly better results in group with time to surgery < 6 months based on shoulder ROM values ($p = 0.01$), elbow ($p = 0.002$), and wrist ($p=0.000$). This is in line with the conclusions of a systematic review conducted by Martin et al., where time to surgery was compared by evaluating muscle strength. It was discovered that the optimal time to delay surgery was 6 months or less, after the injury to obtain the expected healing of muscle strength (Martin et al., 2018). Estrella and Favila observed the effect of time on ROM and discovered no statistically significant difference. However, the absolute



values, namely elbow flexion 88.07° and 77.14° respectively at 6 months compared to >6 months indicated that patients had greater mobility when operated on earlier (Estrella dan Favila Jr, 2014).

The heterogeneous sample size and initial injury management show that this study only assessed the effect of time to surgery from injury on the outcome. Other factors that can also influence the outcome after brachial plexus surgery include the patient, the lesion, and the surgical technique. Previous investigations showed that age also affects motor outcomes, where poorer scores are associated with older age. Coulet et al and Nagano discovered that this was true for patients older than 30 years compared to younger ones (Coulet et al., 2010; Nagano, 1998). According to Terzis and Barbitsioti, patients older than 40 years compared to those below 20 years had better outcomes at younger ages. Therefore, it was suggested that the higher cortical plasticity in younger patients can be a contributing factor to their better recovery (Terzis & Barbitsioti, 2012). The extent of the brachial plexus lesion also affects motor outcomes. Based on the previous discovery, upper brachial plexus lesions involving C5-7 had the best outcome, C8 and T1 lesions had poor results (Suroto, Antoni, et al., 2021), while the worst outcomes were noted when complete lesions occurred (Terzis et al., 1999).

This study evaluates the functional effect based on the VAS, SF36, and DASH scores (Suroto & Rahman, 2021). The results showed that there was a significant difference in the group with time to surgery >6 months compared to <6 months in VAS value ($p=0.000$). Similarly, Kato et al. discovered that the time to surgery significantly affects the VAS score. Based on the results, the lowest VAS was discovered in the surgery that was carried out less than 1 month from the injury with a gradual increase in the VAS value along with a longer delay in surgery. Smaller pain scores also correlate with better rehabilitation, indicating the lower the VAS score, the better the patient's quality of life (Kato et al., 2006). Good return of motor skills is associated with lower VAS values (Choi et al., 1997). This is related to the ability to carry out early rehabilitation to reduce pain in patients who had surgery (Suroto, Putra, et al., 2021)

There was a significant difference in functional evaluation in the group with time to surgery > 6 months compared to < 6 months on both

assessments, namely SF36 ($p=0.003$) and DASH score ($p=0.035$). Patients who had surgery under 6 months were satisfied with the results of the operation (Ahmed-Labib et al., 2007; Dolan et al., 2012). Ahmed-Labib also discovered that patients who had surgery in the >6 months group had a poorer postoperative function, which worsens the longer the time to surgery (Ahmed-Labib et al., 2007). The postoperative functional ability in patients with brachial plexus injury is highly influenced by muscle strength, joint ROM, and VAS values (Martin et al., 2018). The drawbacks of this study include the lack of variety and the number of samples. Pre-operative clinical and radiological data were also not considered, although they may affect the outcome of the surgery.

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Conclusions

The clinical and functional outcome evaluation after nerve transfer was significant, based on pain, quality of life, and level of satisfaction using the Visual Analogue Score, as well as the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire. Furthermore, the clinical evaluation based on ROM, and muscle strength (manual muscle testing) showed significant differences in patients with traumatic brachial plexus lesions who had surgery for a period of < 6 months and > 6 months from the incident.

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