



Literature Review

A literature review of intercostal-to-musculocutaneous-nerve transfers in brachial plexus injury patients: Does body mass index influence results in Eastern versus Western countries?

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Abstract

Background: A wide range of results have appeared in the literature for intercostal nerve transfers in brachial plexus patients. Oriental countries generally have a lower body mass index (BMI) than their occidental counterparts. We analyzed published series of intercostal nerve transfers for elbow reinnervation to determine if a difference in outcomes exists between Eastern and Western series that could be inversely related to BMI.

Methods: A PubMed search was conducted. Inclusion criteria were: (1) time from trauma to surgery <12 months, (2) minimum follow-up one year, (3) intercostal to musculocutaneous nerve transfer the only surgical procedure performed to reestablish elbow flexion, and (4) males comprising more than 75% of cases. Two groups were created: Series from western countries, including America, Europe, and Africa; and series from Asia. Pearson correlation analysis was performed to assess for the degree of correlation between percent responders and mean national BMI.

Results: A total of 26 series were included, 14 from western countries and 12 from Eastern countries, encompassing a total of 274 and 432 surgical cases, respectively. The two groups were almost identical in mean age, but quite different in mean national BMI (26.3 vs. 22.5) and in the percentage of patients who achieved at least a Medical Research Council (MRC) level 3 (59.5% vs. 79.3%). Time from trauma to surgery was slightly shorter in Eastern (3.4 months) versus Western countries (5.0 months).

Conclusions: The percentage of responders to intercostal to musculocutaneous nerve transfer was inversely correlated with the mean national BMI among male residents of the country where the series was performed.

Key Words: Brachial plexus injury, body mass index elbow flexion, intercostal nerve transfer

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INTRODUCTION

Intercostal nerve transfers have been used actively as a tool for elbow flexion reinnervation in traumatic brachial

plexus patients. This technique is originally attributed to Yeomann, working with Seddon.^[23] Reports in the 60s and 70s by Asian surgeons contributed to its popularization, with several other targets introduced later for which

the intercostals were used as nerve donors, besides the musculocutaneous nerve and its branches.^[12,14,22,36] Despite its popularity in the literature, several reports appeared of either frank failure or no better than mediocre results while employing this technique, rendering intercostal to musculocutaneous nerve transfers a second or third choice among axon donor procedures at certain centers in the West.^[1,28,33] In contrast, many others, especially in Eastern countries, still consider this technique to be one of the best alternatives for nerve transfer.^[5,6,14,26,39]

Unfortunately, a major challenge arises when one attempts to statistically assess the effectiveness of any given operative technique in brachial plexus patients. In any single series, the number of patients typically is too small to allow for adequate statistical power. Moreover, other problems arise when you attempt to combine a number of surgical series for statistical analysis, which include heterogeneity of the primary injury, nuances in the surgical repair technique, and the adoption of different postoperative outcomes. In addition, different languages and geographical, social, linguistic, and economical factors might play a role in determining treatment outcomes, though how and to what extent such effects occur generally remain unclear.

Among others, the interval of time between the initial trauma and reparative surgery, and the number of avulsed roots are recognized factors that determine the results of brachial plexus surgery.^[11,17,18,20] Body mass index (BMI), which reflects a patient's weight relative to height, has only recently been reported as yet another prognostic factor, with its influence appearing not to be as strong as the timing of surgery.^[9,31,32]

The objective behind writing the present paper was to analyze all available series involving intercostal nerve transfers for elbow reanimation reported in the literature, in an attempt to determine if any difference in outcomes exists between Eastern and Western countries that could be inversely related to patient BMI, and thereby at least partially explain the dichotomy that exists in the acceptance of intercostal to musculocutaneous nerve transfers in different countries.

MATERIALS AND METHODS

A PubMed search was conducted to identify all series reported in the English-language literature describing the results of intercostal to musculocutaneous nerve transfers to restore elbow flexion. Inclusion criteria for studies were: (1) time from trauma to surgery less than 12 months; (2) a minimum follow-up period of one year after surgical reconstruction; (3) intercostal to musculocutaneous nerve transfer as the only surgical procedure performed to restore elbow flexion; and (4) males comprising more than 75% of reported cases.

Papers were excluded if they contained insufficient information to determine if all four inclusion criteria were met, or if the same group of investigators was suspected of duplicating results reported in another publication; in this latter case, only the most recently published report was included in analysis.

The results of each included series were summarized in a global table that also included the mean BMI among males residing in the participating country in the year of series publication, obtained via census or other national survey statistics stratified by gender and year.^[4]

For group comparisons, countries were allocated either as a Western country, which incorporated the Americas, Europe, and Africa, or as an Eastern country, which incorporated all of Asia. For statistical analysis, means were generated for each patient characteristic and clinical outcome, and then weighted to reflect the number of subjects in each series. Despite the absence of individual patient data, Pearson correlation analysis still could be conducted because it relies on proportions, not means, and thereby has no need of standard deviation or standard error values. Analyzed variables were mean age, time from trauma to surgery, percentage of subjects who achieved a postoperative strength of at least MRC 3, mean BMI for males of each country for the year of series publication, and the number of intercostal nerves used for nerve transfer. The obtained results are organized in tables.

RESULTS

A total of 26 published series were included in the analysis: 14 from countries we considered Western (USA = 6, France = 2, Germany = 1, Holland = 1, Yugoslavia = 1, Denmark = 1, Australia = 1, Egypt = 1), and 12 from Eastern countries (Japan = 7, India = 2, Thailand = 2, Taiwan = 1). The total number of surgical cases was 274 from the West and 432 from the East [Tables 1 and 2]. Weighted means for all the analyzed variables are presented in Table 3. The two geographical groups were almost identical in mean age, but quite different in the percentage who achieved at least an MRC-3 level (59.5% vs. 79.3%) and in mean national BMI (26.3 vs. 22.5). Also, the time from trauma to surgery was slightly shorter in Eastern (3.4 months) than Western countries (5.0 months).

Correlation analysis revealed the percentage of responders to be inversely correlated with the national mean BMI of the country in which the series of procedures was performed, as predicted, with studies conducted in countries with a lower mean BMI generating better results. However, an even stronger inverse correlation was evident between the time to surgery and percentage of responders; note again that the mean wait for surgery

Table 1: 274 cases of intercostal-to-musculocutaneous nerve transfer in Western countries

Source/year	No. of patients	Age (years)	Delay	No. of IC's used	Result: MRC 3/+ MRC 4/+	Country	Mean BMI ²
Sedel ^[29] (1982)	7	17-44 (22.4)	2-14 (7)	57.1% 2 IC	71.4% 0%	France	24.76
Simesen ^[30] (1985)	4	4-70 (21)	4-6	2	0% 0%	Denmark	24.57
Berger ^[1] (1985)	58	?	<6	1-4	53.4% 29.3%	Germany	25.66
Samardzic ^[28] (1992)	7	11-57	2-12 (4)	2-3	43% ?	former Yugoslavia	25.99
Kline ^[15] (1995)	37	13-43 (22)	<5	?	57% 46%	USA	27.18
Ruch ^[27] (1995)	16 ¹	10-42 (21.8)	3-12 (6)	81.2% 3 IC	50% 50%	USA	27.18
Krakauer ^[16] (1995)	8	7-50 (22.4)	1-8 (5.25)	2	75% 50%	USA	27.18
Tonkin ^[35] (1996)	17	17-35 (23.5)	1.5-11 (5.5)	2	64.7% 47%	Australia	26.37
Malessy ^[19] (1998)	25	22.1	<5 (3.35)	84% 3 IC	64% 56%	Holland	25.08
Merrell ^[20] (2001)	10	7-67 (28)	4-8 (5)	90% 3 IC	90% 70%	USA	27.81
El Gammal ^[8] (2002)	20	(27)	(4.9)	3	85% 45%	Egypt	26.23
Sulaiman ^[33] (2008)	9	?	?	?	22.22% ?	USA	28.46
Coulet ^[7] (2010)	17	25±8	5.7±2.3	3	70.5% 41.2%	France	25.87
Terzis ^[34] (2012)	39	26.02±9.63	60.3% <8	84.6% ≥3	56.25% ?	USA	28.46

^[1]: One amputation case was excluded. ^[2]: Among males residing in the country where the study was performed, in the year of paper publication. BMI: Body mass index, MRC: Medical Research Council Scale

was 1½ months shorter in Eastern series. No correlation existed between the mean percentage of responders and the mean number of intercostal nerves used.

DISCUSSION

The data analyzed here demonstrate an inverse relationship between the national mean BMI of males and the results obtained in published series from that country of intercostal to musculocutaneous nerve transfers in brachial plexus patients.

Obviously, one major methodological weakness of our analysis is that the BMI data included for statistical purposes were mean values of the country of paper origin in its year of publication, and not BMI values extracted from the series themselves. The reason for this is a purely practical one: Series-specific data were rarely available. Moreover, we used mean national BMI values for males, while some females were included in the analyzed series. In most instances, however, very few, if any, females were included.

Our analysis also shows that another variable, time to surgery, a variable that has already been recognized as a strong predictor of outcome, exerted an effect. On one hand, this consistency with previously published results adds credence to our analysis. On the other hand, time to surgery might have been a confounder in the relationship we observed between BMI and outcome. Obviously, a prospective study in which BMI is measured preoperatively in all patients would be far preferable to our analysis. However, in the absence of such data, we believe that our analysis does offer potential insights, and is aided by its inclusion of a large number of patients, making it far preferable to simple conjecture or personal anecdotal experience.

These data could help to explain why intercostals are preferred in some Eastern countries as donors in elbow flexion reinnervation procedures, while in the West the technique tends to only be used when no other donor is available. Of course, exceptions exist to this. To date, all the data published regarding the influence of BMI on brachial plexus surgery outcomes, besides being scarce,

Table 2: 437 cases of intercostal-to-musculocutaneous nerve transfer in Eastern countries

Source/year	No. of patients	Age (years)	Delay	No. of IC's used	Result: MRC 3/+ MRC 4/+	Country	Mean BMI ¹
Minami ^[21] 1986	17	?	?	2	100% 71%	Japan	22.19
Nagano ^[22] 1989	149	16-50	88.5% <6	98% 2 IC	69.8% 25.5%	Japan	22.31
Chuang ^[6] 1992	66	17-60 (27)	2-12 (4)	56% 3 IC 44% 2 IC	66.7% 66.7%	Taiwan	22.01
Ochiai ^[24] 1993	21	16-36 (21.8)	1-5 (3.5)	2	76.2% 52.3%	Japan	22.54
Kawai ^[13] 1994	6	17-46 (28)	<3.5 (2)	2-4	100% 83%	Japan	22.62
Ogino ^[25] 1995	10	16-22 (18.6)	1-8 (2.7)	2	90% 70%	Japan	22.69
Okinaga ^[26] 1999	11	16-29 (22.8)	1-6.5 (2.4)	2	100% 63.6%	Japan	23.00
Waikaku ^[38] 1999	75	18-40 (25±6)	2-6 (3.8±2)	3	93.3% 68.5%	Thailand	22.44
Nagano ^[22] 2001	112 ³	4-47 (22)	0.13-9 (3)	2	87% 41%	Japan	23.13
Chalidapong ^[5] 2004	19	(25±8)	<6	2	58.8% 17.6%	Thailand	22.73
Bhandari ^[2] 2009	4	(22.5)	3-4 (3.5)	3	75% 25%	India	20.99
Bathia ^[3] 2011	59	4-51 ²	(3.2)	3	79.6% ?	India	20.99

1: Among males residing in the country where the study was performed, in the year of paper publication. 2: Data extracted from a larger series. 3: Patients from 1982 to 1986 were included in a previous series, published in 1989

Table 3: Weighted means for Western and Eastern samples

	Western countries	Eastern countries
Age	24.0	23.9
Delay	5.0	3.4
No. of intercostals transferred	2.8	2.3
% MRC3	59.5	79.3
% MRC4	41.6	46.1
Mean BMI	26.3	22.5

BMI: Body mass index, MRC: Medical Council Research Scale

demonstrate that this is not as influential a factor as the time from trauma to surgery or the extent of the primary injury. Further data must be collected to make firm conclusions regarding this issue.

It is well known that residents of Asian countries generally have lower BMIs and much lower rates of obesity than their occidental counterparts. Though these differences are trending toward disappearing in the future, at present they still exist. We note, however, that the majority of series included in the present analysis were published in the 80s and 90s. In those decades, the difference in population mean BMI between Eastern and Western countries was greater than it is now.^[37,38] This greater

difference rendered the current statistical analysis more likely to detect significant correlations.

The mean age of the two study groups, East and West, were almost identical. However, Western surgeons tended to use more intercostal nerve donors per procedure: 2.8 versus 2.3 among their Asian counterparts. More intercostal nerves should translate into more axons for the target muscles (each nerve having approximately 200 motor fibers at the anterior axillary line). This difference should favor occidental studies, in terms of results, but clearly does not.^[10] Kawai *et al.* identified no difference using more than two intercostals, even though they demonstrated better results using two versus only a single nerve.^[13] Similarly, in their meta-analysis, Merrel *et al.* failed to demonstrate any influence of the number of transferred intercostals on results, while considering two, three, and four nerves as donors.^[20] In contrast, Chuang *et al.* improved their results using three nerves.^[6]

That the difference in the average delay from trauma to surgery was a bit more than 1½ months longer in Western countries could certainly have played a role in our analysis results. Nevertheless, the mean delay of 5.0 months in the West is still well within the 6-month time window generally recommended for brachial plexus repair surgery.

In fact, many recommend waiting as long as 6 months to allow for any spontaneous reinnervation to occur prior to surgical intervention and its associated risks. That Eastern series tended to involve earlier surgical intervention raises the possibility that some of their enhanced 'surgical results,' in fact, were due to natural healing.

In this study, study error was minimized by limiting our analysis to cases of nonobstetric brachial plexus palsy in adults, all operated upon within one year of trauma and having at least one year of follow-up. As such, we tried to eliminate as many other sources of statistical error and confounding as possible. Nevertheless, some differences between series – like the use of interposed grafts between donor and target nerves, the effect of physiotherapy, and various nuances in surgical technique – could have played a role in the results of each series.

Furthermore, problems like the assessment of results by nonblinded observers, often a member of the surgical team itself, are common in the brachial plexus literature. As such, a prospective study is clearly warranted to determine the true predictive role of BMI and many other variables on the results of brachial plexus surgery using intercostal grafts.

CONCLUSIONS

Data published in the literature seem to favor lower BMI as a predictor of enhanced outcome in intercostal to musculocutaneous nerve transfers. However, future research remains necessary, preferably with all data, including preoperative BMI, collected prospectively and all outcomes assessed by a blinded observer.

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