### Scientific paper session 3: Brachial plexus adults/nerve general
**Introduced and moderated by Michael Fox and Tim Hems**

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Future directions for traumatic brachial plexus injury: Outcomes, natural history and nerve transfers

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Traumatic brachial plexus injuries remain a cause of serious long term disability, with repair and recovery ultimately being limited by biological factors. I would identify three areas worthy of consideration in improving outcomes within current technology.

There is a need to agree on outcome measures. Development of patient rated outcome measures suitable for brachial plexus cases is showing promise. For motor function the medical research council scale has served us well because of its ease of use, but often the range of movement isn’t taken into account. As a minimum, outcomes should include formal measurement of muscle force and range of movement. In addition a record of co-contraction and independence of movement should be made.

We need to explore new methods for predicting the natural history of supraclavicular injuries before carrying out surgical repair. Historic series suggest that significant spontaneous recovery may occur at least after partial injuries affecting the upper plexus. This factor may even have affected recovery observed after nerve transfers. Assessing a lesion at exploration and deciding whether repair will improve the outcome remains difficult in some cases.

The trend towards repair using nerve transfers rather than nerve grafts, needs more critical evaluation. While nerve transfers have increased reconstructive options, some drawbacks, including co-contraction with function of the donor nerve, have been underreported. My own experience suggests that results for shoulder function have been improved by including accessory to suprascapular transfer, whereas outcomes for restoration of elbow flexion have not been substantially changed using nerve transfers.
3.1 Profile of Adult Traumatic Brachial Plexus Injury in Prof. Dr. Soeharso Orthopaedic Hospital Surakarta July 2013- September 2018

T. Sumarwoto
Prof Soeharso hospital, Sukoharjo, Indonesia

The incidence of the traumatic brachial plexus injury today continues to increase. Incidence ranged from 10% of peripheral nerve lesions and approximately 14% of neurologic lesions in the upper limbs is due to brachial plexus lesions. There are various kinds of management of traumatic brachial plexus modalities injury. A retrospective descriptive study was conducted on all adult patients with traumatic BPI in Prof. Soeharso hospital since July 2013 to September 2018. The evaluation was done on the patient demographic data, mode of injury, type, management. 13172 patients have administered in Prof. Soeharso hospital, an average of 3-4 cases per month, 129 men and 43 women. The commonest in productive age with a mean age was 31 years (range 16-63 years). The highest number of 105 cases due to traffic accident due to traction injury. Majority patient’s arrival time: 3 months and 6 months post-trauma (70 cases). 51 cases with concomitant injury, and the most are humeral fracture 25 cases. Complete pre ganglioner type is the most common. External neurolysis mostly conducted as primary reconstruction (30 cases), while SAHA procedures mostly the highest secondary reconstruction procedures (55 cases). A research has conducted on the profile of patients who were diagnosed with traumatic BPI in Prof. Soeharso hospital during July 2013 to September 2018. This research can be a basic data for further research related to the traumatic BPI to provide input for improvement of the capability and outcome of the traumatic BPI management in Prof. Soeharso Orthopaedic Hospital Surakarta holistically.
3.2 Correlation of Magnetic Resonance Imaging (MRI Neurography) and Electrodiagnostic study findings with Intra-operative findings in post-Traumatic Brachial plexus palsy.

M. Thatte, N. Patel
Bombay Hospital, Mumbai, India
3.3 Brachial plexus injury incomplete type C5 C6 C7 treated with neurotization modified oberlin procedure in ortopedi hospital Prof. Dr. Soeharso Surakarta

T. Sumarwoto,
Prof Soeharso hospital, Sukoharjo, Indonesia

Brachial plexus injury (BPI) is a severe peripheral nerve injury affecting upper extremities, causing functional damage and physical disability. The most common cause of adult BPI is a traffic accident. One of type BPI is incomplete type which affected C5 C6 or C5 C6 C7 (Erb’spalsy). The motoric problem these patients are not be able to flex the elbow – extend the elbow (for C5 C6 C7) and also abduct the shoulder joint.

Neurotization is the gold standard for therapy. To overcome the inability flexion the elbow is neurotization to musculocutaneous nerve. Oberlin proposed the neurotization to the muscle branch to biceps of the musculocutaneous nerve from the ulnar nerve, fascicle to the FCU (Oberlin procedure). Later Mc Kinnon complete the neurotization to the muscle branch to brachialis of the musculocutaneous nerve from the median nerve, fascicle to the FCR (Modified Oberlin).

We overview modified Oberlin procedure in brachial plexus injury patient satour hospital Rumah Sakit Ortopedi Prof. dr. R. Suharso Surakarta Middle Jawa Indonesia from Januari 2015 – December 201. There are 19 patients brachial plexus injury upper type, consist 13 men and 6 women, the mean age is 30.3 years old, with the commone stage is at productive age. Average starting flexion the elbow is 6.8 months, with the motoric power (BMRC) are 3,4 and 5, the commonest is 3.

Neurotization is the gold standard therapy for Brachial plexus injury, and by neurotization there is a new hope for overcome inability flexion the elbow.
3.4 Leiden adult traumatic brachial plexus surgery series: outcome of 10 years

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OBJECTIVE The objective of this study was to assess the results of 10 year of brachial plexus surgery in Leiden following supraclavicular traction injury in adults.

METHODS All surgically treated adult patients with traumatic brachial plexus injury at the Leiden Nerve Centre between 2007 and 2017 were retrospectively analyzed. From 2009 onwards, the authors have strived to repair severe lesions as early as possible. Surgical finding and outcome in those who had undergone treatment within 2 weeks after trauma were retrospectively compared with results in those who had undergone delayed treatment. Patients treated with nerve grafting for C5 and C6 reconstruction were compared to patients with Oberlin transfers for reanimation of biceps function. The result of biceps muscle reanimation was the primary outcome measure. Secondary outcome measures were shoulder function, hand function and complications.

RESULTS A series of 131 patients with a minimum follow up time of 2 years was evaluated.

CONCLUSIONS result will follow after publication of data
3.5 Cervical exploration in total brachial plexus palsies: is it worth it?

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Objectives: There is currently no non-invasive and non-irradiating method for determining if a C5 and/or C6 root is graftable or not in complete brachial plexus palsies. The objective was to evaluate the reliability of the clinical examination coupled with MRI as a preoperative planning method.

Methods: We conducted a prospective study from 2013 to 2018. The inclusion criteria were to have a total brachial plexus paralysis and to be older than 18 years old. Claude-Bernard-Horner and irritative syndromes, phrenic and anterior serratus muscle paralysis were investigated. FIESTA 3D sequence MRI was performed for each patient. The surgical exploration of the C5 and C6 roots objectified if they were avulsed and, in case of rupture, assessed the possibility of grafting them.

Results: Twenty-seven patients were included. Serratus anterior testing had a specificity of 100% and its diagnostic efficiency was 78%. The presence of an irritative syndrome had a sensitivity of 100% and its diagnostic efficiency was 93%. MRI had a sensitivity, specificity and diagnostic efficiency of 89% all three. A decision tree to validate or not the possibility of grafting C5 and/or C6 has been developed with a sensitivity and negative predictive value of 100%.

Conclusion: This study approves the interest of this diagnostic method for a better operative planning. In total brachial plexus palsies, it could help to prevent the morbidity of cervical exploration.
3.6 Coaptation of full length n.phrenicus to n.axillaris

M. Kateva
Sofiamed, Sofia, Bulgaria

Objectives: N.phrenicus is a classic extra-plexus donor of axons for re-innervation of the muscles of the upper extremity by performing end-to-end or end-to-side microsurgical anastomoses with nerve-grafts (n.suralis, n.saphenus). A new method of direct neurotisation of n.axillaris with n.phrenicus was presented as n.phrenicus is taken endoscopically in its full length immediately before it sank into the diaphragm. M2 contractions(MRC) of m.deltoideus was reported 4 months postoperatively. A major factor for successful neurotisation is time, most importantly, the donor / recipient nerve distance.

Methods: 5 adult patients with brachial plexus trauma are presented. Our approach to those with C5, C6, C7 avulsion and C8, Th1 neuropraxia was: 3 months after the trauma first stage of surgery treatment is presented- modified Oberlin method for restoration of elbow function is performed, as well as other nerve transfer was also carried out at the same stage: n.accessorius to n. suprascapularis. In the second stage neurotisation of n.axillaris is performed by taking full length of n.phrenicus.

Conclusions: M2(MRC) muscle contractions of m.deltoideus are reported on the 4th postoperative month. The length of the intrathoracic n.phrenicus is 22 cm. This shortens the reinnervation time with 7-12 months. This is a revolutionary method of restoration of affected muscles after plexus brachialis trauma. A major factor in their successful neurotisation is the time. i.e., the donor / recipient nerve distance. The use of n.phrenicus with its full length as a donor shortens the re-innervation time of the impaired muscles.
3.7 Results of phrenic nerve transfer to the musculocutaneous nerve using video-assisted thoracoscopy in patients with traumatic brachial plexus injury: series of 28 cases

M. de Mendonça Cardoso, R.A.G. Amoreira Gepp
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Background: The phrenic nerve can be transferred to the musculocutaneous nerve using video-assisted thoracoscopy, aiming at the recovery of elbow flexion in patients with traumatic brachial plexus injury. There are few scientific papers in the literature that evaluate the results of this operative technique.

Objective: Evaluate biceps strength and pulmonary function after the transfer of the phrenic nerve to the musculocutaneous nerve using video-assisted thoracoscopy.

Methods: A retrospective study was carried out in a sample composed of 28 patients that were victims of traumatic injury of the brachial plexus from 2008 to 2013. Muscle strength was graded using the British Medical Research Council (BMRC) scale and pulmonary function through spirometry. Statistical tests, with significance level of 5%, were used.

Results: In total, 74.1% of the patients had biceps strength greater than or equal to M3. All patients had a decrease in forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV1), with no evidence of recovery over time.

Conclusion: Transferring the phrenic nerve to the musculocutaneous nerve using video-assisted thoracoscopy may lead to an increase in biceps strength of M3 or greater (BMRC) in most patients. Considering the worsening of the parameters of spirometry observed in our patients and the future effects of aging in the respiratory system, it is not possible at the moment to guarantee the safety of the operative technique in the long term.
3.8 Geographical and population-based factors that can play a role in our BPI surgery results

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²Leiden University Medical Center, Leiden, Netherlands
³University of ULM, Argentina

BACKGROUND: Among other factors, like the time from trauma to surgery or the number of axons that reach the muscle target, a patient’s age, his body mass index and the country where he comes from might also impact the final results of brachial plexus surgery.

OBJECTIVE: To identify any correlations between age, body mass index, country of origin and the outcomes of BPI surgery.

METHODS: A literature analysis of some of our published series were analyzed. Univariate, univariate trend, and correlation analyses were conducted with patient age, body mass index, country of origin, time to surgery, type of injury, and number of injured roots included as independent variables.

RESULTS: A statistically significant trend toward decreasing mean strength in elbow flexion, progressing from the youngest to oldest age group, was observed. There were no differences by age group in final shoulder abduction range or the percentage achieving a good shoulder outcome. Similarly, BMI did predict shoulder abduction range of motion, but not percentage of strength or BMRC grade recovery for biceps flexion. Comparing patients many different countries shows different epidemiological trends.

CONCLUSION: Our data suggest that age, BMI and patient geographical origin are somehow linked to the outcomes of brachial plexus surgery. According to this results, extreme care should be taken at the moment of interpreting any published material on brachial plexus reconstruction.
3.9 Age as a Predictor of outcomes in Patients with upper Brachial Plexus injuries Undergoing Surgical Repair

R. Sharma, S. Gaba, M. Modi
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Introduction: Brachial plexus injury (BPI) is a severe peripheral nerve injury affecting upper extremities, causing functional damage and physical disability. The aims of this study are to determine any correlations between age and the outcomes, satisfaction, and the degree to which patients’ expectations were met.

Method: 15 Patients who were seen for upper BPI were recruited. The patients were divided into two groups. Group A included patients from 18 to 40 years of age (n=10) and group B included patients 40 years of age (n=5). Detailed history and relevant clinical examination, motor examination based on the medical research council grading (MRC) to estimate limb and axial muscle strength done. Electrodiagnostic test were done preoperatively and post operatively at various time points.

Results: A statistically significant trend toward decreasing mean strength in elbow flexion, between the two groups, was observed. at six months and at 1 year postoperatively between the two groups. A statistically significant difference in shoulder abduction at 1 year postoperatively was seen.

Conclusion: Our data suggest that age is somehow linked to the outcomes of upper BPI with respect to elbow flexion and shoulder abduction strength. Increasing age is associated with steadily worsening outcomes, perhaps indicating the need for earlier surgery and/or more aggressive repairs in older patients. Early diagnostic assessment, correct timing of surgery and appropriate rehabilitation are crucial to obtain a rewarding outcome.
3.10 Brachial plexus lesions in shoulder dislocations and fractures of humeral neck in the elderly

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Shoulder dislocation is a very common injury described mainly as a diagnosis of young people. Indeed about 20% of first-time dislocations occur in people older than 60 years of age, partly with severe complications like nerve lesions or axillary artery injuries.

In a retrospective analysis 31 patients with shoulder injuries in combination with nerve lesions and lesions of the axillary artery were listed between 2013 and 2018. 15 patients suffered on a traumatic nerve lesion. The nerve lesion occurred after reposition in 6 cases, postoperatively 5 times. The treatment of such nerve lesion was mainly conservative. A compression by hematoma caused by a lesion of the axillary artery in 3 cases or by anticoagulant therapy in 1 case led to additional nerve lesions. In these cases operative treatment were done followed by reinnervation.

The follow up from 1 month to 3 years was not really consistent – might be caused by the age of the patients. 6 patients were completely missed. In 11 cases incipient reinnervation was observed. In 1 case poor reinnervation remained despite neurolysis and in 5 cases only partial reinnervation was achieved. 8 Patients showed advanced reinnervation.

Results show a reinnervation in the majority. But deficits remained in a few cases. The greater focus on shoulder dislocations and their complications in younger people in the literature may lead to less attention to the higher risk and rate of complications in the elderly. A high awareness of the possibility of severe additional lesions is therefore important in treatment.
3.11 Brachial plexus injury as a complication of anterior shoulder dislocation is associated with long term functional deficits

Leeds Teaching Hospitals NHS Trust, Leeds, United Kingdom

Aims: Anterior shoulder dislocation is a common injury that may occur from a fall or other traumatic mechanism. Brachial plexus injury is an infrequent but important complication and literature on functional outcomes is limited. We aimed to observe the recovery patterns of individuals with this injury.

Methods: Over two years, we monitored a cohort of consecutive patients with a brachial plexus injury due to anterior shoulder dislocation. Muscle power according to the Medical Research Council (MRC) scale and sensation was measured at baseline and until discharge. Median (with interquartile range, IQR) recovery are compared with the Sign-Rank test. The relationship between age and recovery is estimated by non-parametric regression.

Results: Twenty-eight patients were included. The mean age was 52 years (SD 14). Nine injured nerves (13%) failed to improve their MRC score over a median follow-up of 5 months (IQR 3, 12; range 1-22 months). Advancing age increased the risk of failure to improve at least one point on the MRC scale, whereby every decade of life increased the risk of no improvement in MRC score by approximately 30%. There was no statistically significant improvement in sensation of any dermatomes over a median follow-up of 6 months (IQR 3, 9; range 1-22 months). Fifty-two percent of sensory abnormalities failed to improve.

Conclusions: Anterior shoulder dislocation associated with a brachial plexus injury carries a significant risk of permanent nerve injury. Better recovery is observed in younger patients. All such patients should be referred for nerve rehabilitation therapy.
3.12 New strategy Surgery in C8T1 paralysis of the brachial plexus.

Z.B. Belkayar,
Clinique du Mont-Louis, Saint Ouen, France

The psychoanalytical paralysis of C8T1 remains the opening of long fingers and thumb.
Tendon transfers to restore extrinsic volar aspect of the hand are classics.
With the brachioradial on the long thumb flexor and the short radial extender of the carp on the deep flexors.
A arthrodesis Trapézo metacarpal for stabilizing the thumb.
Then a transfer of the biceps to the extensors of the long fingers and the thumb with a fasciae latta graft to restore the opening of
6 weeks of immobilization Elbow In bending.
A short physiotherapy.
The opening and closing of the hand is restoring with very good video results.