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2.1 Tension on peripheral nerve suture

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It is shared common knowledge that a peripheral nerve suture should be done without undue tension. After a literature review and confrontation with clinical situations where the nerve gap could be reduced and tension neutralized by specific suture material, we designed a surgical strategy to repair selected upper and extended upper obstetric brachial plexus lesions by neuroma excision at the trunk level and direct suture-coaptation. As the clinical outcome in a retrospective cohort was rather good after more than 2 years of follow up, we continued to work on this paradigm and biological conditions for nerve regeneration and present our state of knowledge for discussion.
2.2 Exploration of Fascicular Shift Procedure in OBPL

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Introduction: Modality matched grafting has proven to provide best results in nerve regeneration. These grafts are obviously difficult to obtain in an autologous setting and thus expandable sensory nerve grafts remain the gold standard to overcome nerve defects. Recently we have investigated the use of sensory-motor fascicles distal to the defect to bridge the gap. Here we present the use of fascicular shifts and long term outcome in a cohort of 4 children that suffered global plexopathies.

Material and Methods: In four children with severe Narakas IV lesions, autologous nerve grafts have been harvested from various trunc nerves distal to the lesion to overcome the devastating defect of all five roots. Intraoperative documentation of cases and cadaveric specimen are presented to depict the various options to harvest expandable fascicles. Finally, more than three year follow-ups are provided with video material and the classic scores for shoulder, elbow and hand function.

Results: This material proves the feasibility of modality matched grafting using fascicular shifting both from cadaveric material and a first cohort of 4 OBPL patients. The data provided indicates that even in the face of a global plexopathy the entire defect can be grafted and a good outcome can be achieved.

Conclusion: The cadaveric data indicates the various regions of the brachial plexus where sufficient length of fascicular material can be harvested. Longterm follow-up data proves that using fascicles distal to the injury can help to overcome the bottleneck in nerve regeneration and a good outcome can be achieved.
2.3 Shoulder outcomes following primary nerve reconstruction of neonatal brachial plexus palsy: Analysis of predictors and surgical strategies

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Methods to re-animate elbow flexion can be reliable whereas reconstruction of shoulder function remains inconsistent and suboptimal. The purpose of this study was to assess shoulder motor recovery following primary nerve reconstruction in order to identify factors that may affect outcome.

Methods: Retrospective review of all infants undergoing nerve reconstruction for NBPP was conducted. Indications for surgery followed the Toronto protocol. Pre-operative and 2-year post-op active movement (abduction, flexion, and external rotation) was assessed. Changes and differences were assessed by ANOVA and subgroup analysis involved Wilcoxon test.

Results: Over an 8-year period 450 patients presented to our center. Forty-eight patients underwent nerve reconstruction. Two patients were excluded given that they underwent isolated distal nerve transfers for elbow flexion alone. Overall, there were significant improvements in abduction, flexion, and external rotation (0.05). Palsy type, number of avulsions, and head injury were associated worse outcome. In order to control for timing and initial severity, subjects were grouped by surgical indication. We found no difference when nerve grafts were combined with nerve transfers or when nerve transfers alone were used. There was an association of number of cable grafts and abduction and external rotation (0.05).

Conclusions: Shoulder function improved significantly following primary nerve reconstruction. The greatest changes were in subjects with more severe palsies. Nerve transfers as adjuncts to nerve grafting may have facilitate these larger changes, however, the role of additional adjunctive transfer in improving outcomes requires larger study of subjects isolated by specific surgical indications.
2.4 Double nerve transfer for shoulder external rotation restoration in OBP

F. Soldado,
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Aim:
To analyze the outcomes following Double nerve transfer for shoulder external rotation restoration in OBP

Methods:
Indication:
OBP with absence of active shoulder external rotation at 18 months of age.

Technique:
SAN to nerve to the infraspinatus by a dorsal approach. Nerve to the long head of triceps to the nerve to the teres minor by a axillary approach. Active shoulder external rotation in ABD is evaluated.

Results:
Fourteen patients were operated. Mean age 19.3 months, mean follow-up 13 months.

Mean aERABD 62 (45-80)

Conclusions:
Double nerve transfer for shoulder external rotation restoration in OBP
2.5 Mid-term Outcome after Selective Neurotization of the Infraspinatus Muscle in Patients with Brachial Plexus Birth Injury

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Hypothesis: Active shoulder external rotation (ER) in adduction and abduction can be restored by selective neurotization of the infraspinatus nerve using the spinal accessory nerve in patients with brachial plexus birth injury (BPBI).

Methods: 14 consecutive BPBI patients with active external rotation in adduction of less than 10° and active shoulder elevation above 90° underwent neurotization of the infraspinatus nerve at median age of 2 years (range, 1.4-4.7) between 2012 and 2016. Pre-operatively all patients had congruent shoulders with passive ER in adduction of 45°. Winging of the scapula was evident in 8/14 patients. Clinical follow-up was scheduled at 3, 6, 12, 24 and 36 months after surgery. Pre- and postoperative EMG was done to 7 patients. Parents’ satisfaction of the functional and cosmetic result was obtained at median follow-up time of 3.8 years (1.6-5.4).

Results: The median improvement of ER in adduction was 52° (range 40°-95°) in 12/14 patients. Two children developed internal rotation contracture of their shoulders with no improvement in active ER in adduction. Shoulder ER in abduction improved in all patients median 52° (range 30°-85°). All seven patients with EMGs showed recovery of infraspinatus function. Pre- (8) and postoperative registered (3) winging of the scapula decreased during follow-up. Hypertrophic scars were observed in seven patients. All but one patient’s parents were satisfied.

Summary points: Functionally significant active external rotation can be restored and maintained by direct neurotization of the infraspinatus muscle in BPBI patients with congruent shoulder joints and no internal rotation contracture.
2.6 Sensibility of the Hand in Children With Conservatively or Surgically Treated Upper Neonatal Brachial Plexus Lesion

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BACKGROUND The aim of this study was to assess the sensibility of the hand in children with a neonatal brachial plexus palsy (NBPP) involving the C5 and C6, and to correlate results with dexterity.

METHODS Fifty children with NBPP (30 after nerve surgery, mean age 9.8 years) and 25 healthy controls (mean age 9.6 years) were investigated. Sensibility was assessed with two-point discrimination and Semmes-Weinstein monofilaments. Dexterity was evaluated with a single item from the Movement Assessment Battery for Children-2. We compared the affected side with the nondominant hand of the control group.

RESULTS The sensibility in the first and second fingers was significantly diminished in the NBPP for both two-point discrimination (P=0.005 and P=0.014, respectively) and monofilament test (P 0.001). Dexterity was significantly lower in the NBPP group than in control group, corrected for age (P=0.023). There was a significant difference toward decreasing hand function with decreasing sensibility according to the Semmes-Weinstein test for the thumb (Jonckheere-Terpstra nonparametric trend test, P=0.036).

CONCLUSIONS The sensibility of the thumb and index finger in children with an upper plexus lesion (either surgically or conservatively treated) is diminished. The decreased sensibility has a negative impact on hand function. Appreciation of diminished hand function in patients with NBPP involving C5 and C6 is important to optimize treatment.
2.7 The Hand-Use-at-Home Questionnaire to assess spontaneous hand-use in children with unilateral paresis: evidence for validity and reliability

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Introduction: We developed the parent-rated Hand-Use-at-Home questionnaire (HUH) to assess the amount of spontaneous use of the affected arm/hand in daily-life activities in children with unilateral paresis, aged 3-10 years. This study describes its development and examination of the internal structure, unidimensionality, validity and test-retest reliability.

Patients and methods: Children with Unilateral Cerebral Palsy (UCP) or Neonatal Brachial Plexus Palsy (NBPP) and Typically Developing children (TD) participated. Rasch-analysis was used to examine the rating scale and internal structure of the questionnaire. Test-retest reliability and construct validity was established. Intra-Class-Correlation (ICC), Standard-Error-of-Measurement (SEM) and Smallest-Detectable-Change (SDC) were calculated. Construct validity was determined by comparing HUH-scores between groups (UCP/NBPP/TD), within levels of lesion-extent in NBPP and Manual-Ability-Classification-System (MACS) levels in UCP.

Results: The development-cohort consisted of 322 children (mean age 6.7 years, UCP:n=131/NBPP:n=191) and the validation-cohort of 315 children (mean age 6.8 years, UCP:n=79/NBPP:n=181/TD:n=55). Eighteen hierarchically ordered bimanual items fitted a unidimensional model. HUH-scores ranged from -4.69 to +5.17 logits. Test-retest reliability was excellent (ICC=0.89). Agreement was high with a SEM=0.60 and SDC=1.66 logits. The HUH discriminated between groups (TD/NBPP/UCP): H(2)=118.985; 0.001, supporting construct validity. HUH-scores decreased with greater lesion-extent (r=-0.5) and higher MACS-levels (r=-0.4).

Conclusion: The Hand-Use-at-Home questionnaire has good psychometric properties and validly quantifies the amount of spontaneous use of the affected arm/hand in children with unilateral paresis, aged 3-10 years. The HUH questionnaire is a valuable addition to the current assessment of children with unilateral upper-limb paresis and provides clinicians with more insight in daily-life upper limb performance.
2.8 Assessing Arm Use in Children with Neonatal Brachial Plexus Palsy (NBPP)

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Objective: Assessment of patient-initiated function is critical in NBPP. Typical methods include range of motion (ROM), muscle strength, and the Mallet instrument: these clinician-elicited measures may not reflect spontaneous arm use in everyday settings. Recent advances in body worn sensor technology have made it possible to objectively measure arm movement in the real world, as we have previously demonstrated in adults. We aimed to demonstrate the utility of this technology in patients with NBPP.

Methods: Nine children with NBPP (11 ± 2 yo) were recruited sequentially from the University of Michigan Brachial Plexus Clinic. Participants wore accelerometers on each arm during waking hours for 7 consecutive days. Duration and magnitude of arm use were expressed as the ratio of affected to unaffected arm use. Ratios were correlated with traditional clinic-based assessments.

Results: Patient compliance and tolerance of the study devices were excellent. Mean duration of use ratio was 0.87, and mean magnitude of use ratio was 0.67. Duration and magnitude correlated strongly with shoulder flexion (r=0.87, p = 0.002), abduction (r=0.87, p = 0.002), and extension (r=0.70, p = 0.035). Surprisingly, no significant correlations were found with elbow or hand Active ROM.

Conclusion: We demonstrate in this proof-of-concept study that accelerometry is an ideal functional measurement as it captures and incorporates all WHO-ICF domains, contrary to typical clinician-elicited assessments. Similar to adults recovering from BPP, children with better shoulder ROM used the arm significantly more, thereby suggesting the importance of shoulder function to overall arm use in this population.
2.9 Outcome assessment for Brachial Plexus birth injury. Results from the iPluto world-wide consensus survey and update on PRO measures

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There is no consensus regarding strategies to optimally treat children with a brachial plexus birth injury (BPBI). Comparison of outcome data presented by different centers is impossible due to the use of (1) many different outcome measures to evaluate results; (2) different follow-up periods after interventions; and (3) different patient ages at the time of assessment. The goal of iPluto (international PLexus oUtcome sTudy grOup) was to define a standardized dataset which should be minimally collected to evaluate upper limb function in children with BPBI. This dataset must enable comparison of the treatment results of different centers if prospectively used.

Three rounds of internet surveys were used to reach consensus on the dataset. A Delphi-derived technique was applied using a nine point Likert scale. Consensus was defined as having attained a rating of 7/8/9 by 75\% of the participants. A total of 59 participants from five continents participated in the Second and Third Rounds of the survey. Consensus was reached regarding four elements: (1) evaluation should take place at the age of 1/3/5/7 years; range of motion in degrees should be measured for (2) passive joint movement; (3) active range of motion; and (4) the Mallet score should be determined.

Consensus on how to assess and report outcome for BPBI was only reached on motor items from the "Body Function and Structure" domain. Consensus regarding PRO measures is the goal of the current survey rounds, of which the current status will be presented.
2.10 Beyond Movement for Children and Adolescents who have required OBPI Primary Repair: Does their movement impact their occupation and quality of life?

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Objective: Explore the relationship between movement, pain, occupational performance, self perception and quality of life (HRQoL) in school aged and adolescent clients who had primary repair of an obstetrical brachial plexus injury (OBPI)

Subjects: 16 participants aged 9-18 years, who had been followed prospectively in the OBPI clinic at McMaster Children’s Hospital.

Methods: Cross-sectional design using prospective assessments and retrospective chart review.

Measures: Body Function and Structures: Active Movement Scale (AMS), Mallet, Modified Pain Faces Scale (mPFS). Activities and Participation: Brachial Plexus Outcome Measure (BPOM), Self-Perception Profiles for Children or Adolescents (SPP), Kid Screen-27 (KS-27), Canadian Occupational Performance Measure (COPM).

Results: 11 male and 5 female with primary repair at 4-7 months. Statistically significant regression of movement (pre-surgery and current AMS: P=.001; 2 year and current AMS: P=.007). 73% of reported pain in their affected UE. BPOM significantly correlated with the AMS (r=.798 P=.000) and Mallet (r=.627 P=.012). 94% had occupational performance goals. SPP and KS-27 trended lower than peer related norms.

Conclusions: Movement regresses over time. Episodic pain is reported in the affected UE. Presence of Occupational Performance goals. HRQoL trended lower than age and gender norms.

Research and Practice Implications: Informs our assessment of this patient population over time aligning with ICF along with the work being conducted by national and international evidence based consensus groups (ie, iPLUTO). Guidance of larger sized, mixed method studies to further our understanding and treatment of OBPI and it’s impact over time.