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Indications of intercostal nerve transfer

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This presentation is a short introduction of history and current indications of intercostal nerve transfers. The first nerve transfer with intercostal nerves was reported by Yoeman and Seddon, who attempted in 1963 a transfer between the intercostal and musculocutaneous nerves using an interposed ulnar nerve graft. In 1968, Tsuyama and Hara described a nerve transfer technique in which the intercostal nerves were directly coapted to the recipient nerve. Since then their technique has been a standard basic technique when we treat the intercostal nerves as donor motor source of neurotization for 50 years. On the other hand, the indications of intercostal nerve transfers, especially in obstetrical brachial plexus palsy, have widely expanded and its concept has considerably changed for the same period. We are now using the intercostal nerves as a main motor source in pure upper root avulsion cases, a supplementary motor source in cases with multiple root avulsions in the lower roots, a salvage procedure for cases in which reanimation of the elbow flexion is failed after spontaneous recovery or post-nerve grafting recovery, and relief for co-contraction of the biceps and triceps muscles. It is also used as a donor nerve for free gracilis muscle transfer, transfer to the various motor nerves other than the musculocutaneous nerve, and sensory reconstruction of the hand.
8.1 An assessment of fatigue and co-contraction of renervated elbow flexor muscles

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INTRODUCTION: Improvements in the evaluation of outcome following Peripheral Nerve Injuries (PNI) are required. Studies have shown that peak volitional force (as assessed by MRC grading) is not predictive of the subjective patient experience of muscle reinnervation. Subsequent focus groups and qualitative studies of nerve injured patients have identified muscle fatigability as a central theme of muscle reinnervation. This study aimed to characterise fatigue in a standardised surgical model of muscle reinnervation.

METHODS: This study recruited 12 patients who were at least 1 year post-Oberlin nerve transfer to reinnervate elbow flexors (biceps-brachialis). Fatigue was objectively assessed by repeated and sustained isometric contractions of the elbow flexor muscles using a Handheld Dynamometer. Co-contraction was concurrently assessed by surface EMG (sEMG) ratios of biceps to triceps. This protocol was executed in the nerve injured arm and the contralateral uninjured arm of participants.

RESULTS: Nerve injured arms demonstrated significantly earlier fatigability (0.01 paired t-test) in the sustained model of fatigue assessment. Re-innervated elbow flexor muscles manifested a shift in sEMG frequency spectra to a range associated with Type 1 muscle fibres (20-125Hz). Co-contraction ratios were higher in reinnervated muscles compared to uninjured muscle in repeatability and sustainability assessments of fatigue.

CONCLUSIONS: This study presents clinically relevant characteristics of reinnervated muscle and has demonstrated how this differs from uninjured muscle. Adoption of these metrics into clinical practice and outcomes assessment will allow a more meaningful comparison to be made between differing treatment options and drive advancements in motor recovery therapy.
8.2 Why do elbow flexion nerve transfers work better than shoulder abduction transfers?

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Background: Peripheral nerve transfers have proven utility in the treatment of upper trunk injuries. Nerve transfers to restore elbow flexion tend to have greater efficacy than those to restore shoulder abduction and external rotation. We have reviewed the results of these transfers in our infant and adult patients to try to determine the reason for this discrepancy.

Methods: A retrospective review was performed of infant and adult patients with isolated upper-type brachial plexus injuries treated with nerve transfers. Recovery of elbow flexion and shoulder abduction was evaluated using the MRC scale. Regression analysis was performed to explore the relationship between time to surgical intervention and outcome.

Results: 100% of adults and 80% of pediatric patients achieved =M4 strength in elbow flexion. 33% (3/9) of adults and 50% (3/6) of infants recovered =M4 strength in shoulder abduction. Regression analysis demonstrated a significant decrease in shoulder abduction strength in adults when nerve transfers were delayed beyond 5 months after injury. Similar delays had no significant effect on our neonatal patients.

Conclusion: Adults, unlike neonates, exhibit a time-dependent decline in shoulder abduction muscle strength when surgical intervention is delayed beyond 5 months post-injury; whereas, neither group demonstrates a decrement in elbow flexion strength for transfers delayed up to one year. These observations can be explained by delayed reinnervation due to the longer nerve regeneration distances to the deltoid and supraspinatus in adults. We therefore recommend that transfers to the axillary and suprascapular nerves in adults be completed by 5 months post-injury.
8.3 Long head of triceps transfer to gain elbow flexion in 15 patients

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Elbow flexion is the most important function of the upper extremity, hence loss of this function leads to a major disability. Elbow flexion deficit can be seen in both traumatic and obstetric brachial plexus palsy conditions. We describe our results for the surgical technique of transfer of the long head of triceps transfer in these cases. We performed this transfer in 15 patients, ages between 2-45 years. The nine adult patients were suffering from traumatic brachial plexus injury while 6 young patients were obstetric palsy sequela. We achieved 85-115 degrees of elbow flexion in obstetric and traumatic plexus patients while preserving elbow extension.

All patients were happy to gain hand to mouth function, elbow extension deficit is acceptable in acquired cases, partial triceps power loss almost never affects daily living.

Although there are many muscle transfer methods (lat dorsi, pectoralis etc) to reanimate elbow flexion, we conclude that long head of triceps transfer is a reliable technique in both traumatic and obstetric palsy cases.
8.4 Efficacy of Intercostal nerves transfers in cases of total brachial plexus paralysis

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In cases of complete brachial plexus palsy (BPP) with multiple spinal nerve avulsions extraplexal nerve transfers to selected targets is the only means to obtain useful function of the involved upper extremity. The Intercostal nerve (ICN) is a well-known donor for brachial plexus (BP) reconstructions. However, there are some controversies concerning the indications and different technique versions. Forty-eight patients with BPP underwent ICN transfers in our center (40 adults and 8 children). ICN transfers to the musculocutaneous (MC) nerve or its branches were performed in 37 cases. In 11 cases ICN were used for neurotization of free gracilis muscle transfer. In all cases only direct coaptations of ICNs and recipient nerves were used. The number of ICNs used depends on the target: main MC – 5 (adults) and 3 (children), branch MC to the biceps – 3(adults) and 2 (children), nerve of free gracilis muscle – 3 and 2. Branches of MC to brachialis muscle previously neurotized by ICNs were utilized in 5 patients with free gracilis muscle transfer. In our series only 4 (8%) patients did not obtain useful function after ICNs transfers. In 44 (92%) cases patients received sufficient muscle power M3-M4 (MRC). Our favorite method for complete BPP with multiple avulsions is the transfer of five ICNs to the main trunk of MC for reinnervation of both biceps and brachialis muscles followed by the use of the nerve branch to the brachialis muscle for free gracilis muscle transfer for finger flexion or wrist extension.
8.5 Intercostal nerve transfer for patients with brachial plexus birth palsy

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Introduction: In patients with brachial plexus birth palsy (BPBP) successful outcomes have been shown for elbow flexion reanimation. Results of the use of ICN to restore other functions have not shown to be as promising.

Objective: Describe the results of ICN transfers for patients with BPBP.

Methods: Retrospective analysis of results of ICN transfers performed in a single institution from January 2010-July 2018. Postoperative motor function was evaluated by a licensed occupational therapist using the Active Movement Scale (AMS). Patients with 6 months of follow-up and sufficient documentation were included.

Results: Twenty-seven patients had BPBP reconstruction using ICN, 92% had global injuries. ICN was transferred to: musculocutaneous nerve (MSC) in 13 patients, 6 patients to biceps branch, 3 patients triceps branch, 3 patients to reanimate both biceps and triceps, one patient for middle trunk and one to radial nerve (after the exit of triceps branch). Excellent outcomes (AMS 6/7) were found in 85% of patients with ICN-MSC nerve transfer, 33% ICN-Biceps branch, 33% to ICN-Triceps branch. 2/3 of patients with transfer to biceps and triceps had excellent outcomes, but only for one function (either flexion or extension). Patients with insufficient function (AMS 5) had surgery at a median of 9 months (range 2-19) compared to 4 months (range 2-6) in patients with excellent outcomes.

Conclusion: ICN transfers for patients with BPBP have mixed results. Excellent outcomes were seen in a higher number of patients with transfer to the musculocutaneous nerve. Patients with insufficient outcomes had surgery at a later age.
8.6 Lower Trapezius Transfer for Triceps Function in Obstetric Palsy; Review of Other Methods and Presentation of 15 Cases

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Since elbow extension is a passive movement when shoulder is adducted and at secondary importance comparing elbow flexion, muscle transfer to triceps is not commonly mentioned in obstetrical palsy literature. This need was observed specially in patients whom had improved shoulder abduction with surgery but have limited elbow extension. Previously, we had operated on 13 patients with elbow extension restoration ages between 5-16 years. We used brachioradialis muscle in 6 patients, brachialis muscle in 6 patients and posterior deltoid muscle in one patient with pros and cons of each method.

Later on depending on the anatomic studies for lower trapezius transfer in order to have better shoulder external rotation, we used ipsilateral lower trapezius muscle by elongation with tensor fascia lata graft to triceps muscle, in 15 obstetric palsy cases. Average elbow extension was improved 50 degrees and shoulder abduction was improved 35 degrees in our patients. Ipsilateral lower trapezius transfer is a good technique for triceps function restoration with minimal donor side morbidity.
8.7 Wrist extension restoration by FDS transfer in residual OBP

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Aim:
To evaluate the outcomes of wrist extension restoration by FDS transfer in residual OBP.

Methods:
Eleven patients (M7,F4). Mean age 9y (range 6-14). Type of injury (C5-C7 10, Total 1). Indication:
Wrist extension BMRC <4. Pre and postop BMRC, grasp

Results:
BMRC preop M3 n=5, M4 n=6 / postop M4 n=11
Mean grasp preop 1Kg (0-1), postop 4Kg (3-5)
Mean pinch preop 2.5Kg, postop 3 Kg
and pinch strength was evaluated.Techique: Transmembrane FDS iii-IV to the third metacarpal

Conclusions:
The transfer of FDS III and IV is effective in wrist extension restoration in residual OBP
8.8 Natural history of Elbow Flexion contracture in Obstetric Brachial Plexus Injury

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A study was undertaken to investigate the severity and progression of flexion contracture of the elbow in patients with obstetric brachial plexus injury (OBPI).

Our service provides management of children with OBPI from the whole of Scotland. Range of movement measurements are recorded at each clinic visit and entered into a database. We aim to review children who have a persisting deficit after OBPI at least until skeletal maturity (Age 16 years), with clinic visits every one to two years. Some patients are also reviewed at an older age. We reviewed measurements of flexion contracture of the elbow, in patients who had not had repair of nerves innervating elbow flexion, together with information on the severity of the initial injury.

Results were available for 156 patients with a mean age of 12 years at last follow-up. There were 55 patients with Narakas group 1 lesions, 67 group 2, 24 group 3, and 10 group 4, with mean age of recovery of elbow flexion of 4, 5, 7, and 11 months respectively. Mean fixed flexion of the elbow at last clinic follow up was 14° (range 0 – 40) for Narakas group 1, 15° (0 – 50) for group 2, 19° (0 – 45) for group 3, and 24° (10 – 40) for group 4.

Children with more extensive OBP lesions are more at risk of severe elbow contracture, which starts to develop before the age of 5 but does not appear to increase substantially beyond the age of 10.
8.9 Elbow Flexion Contractures in Brachial Plexus Birth Injury: Function and Appearance Related Factors

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8.10 Shared Decision Making in Youth with Elbow Flexion Contractures Secondary to Brachial Plexus Birth Injury

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Introduction and Objective: To explore the shared decision making experiences of youth with brachial plexus birth palsy (BPBI) and their families when making preference-sensitive decisions regarding rehabilitation and surgical treatment options for an elbow flexion contracture.

Materials and Methods: An interpretivist qualitative approach was used to conduct a decisional needs assessment to develop a patient decision aid (PtDA) for youth and their families using two qualitative sources: in-depth interviews with 5 young adults and 14 youth-parent dyads, and 15 participant observation sessions of families and clinicians in the clinic setting. Both text-based field notes and in-depth interview transcripts were coded deductively and inductively, followed by thematic analysis.

Results: In the context of using a PtDA to support youth to make elbow treatment decisions, shared decision making was influenced by 1) An irreconcilable view of the elbow’s effect on activity limitations and participation restrictions; 2) Social concerns related to the visibility of the contracture, 3) Trust in the expertise of the clinician; 4) Youth’s role in the decision and parental emotional adjustment to BPBI; and 5) Youth-parent decision discord. These themes all carry important clinical implications and require an approach to shared decision making that recognizes and emphasizes the significance of social and emotional factors that affect a family’s shared decision.

Conclusions: By revealing the complexities of shared decision making in youth with BPBI, this research reflects the real-world concerns of these families when using a PtDA to help youth with BPBI make treatment decisions regarding an elbow flexion contracture.
8.11 How the rotational balance of the shoulder affects prosupination

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Introduction: Upper limb motion may not only be analysed in terms of isolated muscle activities or agonist / antagonist couples, but also considering motion "chains" linking for example arm and forearm positions and motion capacities. In obstetric palsy, the glenohumeral rotational balance is often disrupted into a medial rotation contracture and this affects active and passive forearm prosupination.

Material and methods: In a patient cohort affected by obstetric palsy, an independant observer measured both active and passive lateral and medial rotation capacities of both healthy and affected shoulders and accordingly active and passive prosupination.

Results: We show and discuss the obvious changes in active and passive prosupination in healthy and affected limbs due to various degrees of rotational glenohumeral imbalance, a striking and constant feature.

Discussion and conclusion: The "chain" concept seems complicated, but is a clinical reality in healthy and affected subjects through different ages and degree of impairment. When recording isolated motion data relevant to a single joint or muscle, without considering agonist /antagonist effects (eg co-contractions) nor transsegmental changes like the here shown chain-effect, incomplete and sometimes wrong views on pathophysiology and surgical decisions may occur. This concept, although sometimes stated, needs further assessment through objective motion recording and multimodal analysis. As we are actually ongoing in this research, we today may just present observational results cited above and hope to bring further biomechanical insights until the symposium.