Brachial Plexus Injuries: Making Sense of It All
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Outline

• Anatomy
• Classification of Nerve Injuries
• Mechanism of Brachial Plexus Injuries (BPI)
• Assessment of BPI Injury and Patient
• Goals of Treatment
• Treatment Options
• Cases

Does your upper extremity matter?

Mallet Classification
Imagine if you can't move or feel your upper extremity

The Brachial Plexus

- Is the set of nerves originating from the ventral rami of C5, C6, C7, C8 and T1 spinal nerves that become the terminal branches that animate and provide sensation to the upper extremity.

Bob Thomas Drinks Cold Beer
Motor

Sensory Dermotomes

Seddon (1942) & Sunderland (1951) Nerve Injury Classification

Neurapraxia -> No Wallerian Degeneration

Neurotmesis fails in order:
Motor, Proprioception, Touch, Temp, Pain, sympathetic

Sunderland 3 & 4: Progressive intrafascicular fibrosis
Pathophysiology of Injury

- Axons regenerate 1 – 2.5 mm/day (30 cm = 300 mm = 300 days = 10 mos)
- Axons do not immediately start regenerating
- “Time is muscle” – motor endplates dissipate by 1 – 1.5 years
- You want innervation within a year
- Muscle atrophy: 50% loss of fiber diameter after 2-3 months

Mechanisms of Brachial Plexus Injuries

- Traction
  - High energy
  - Low energy
- Gunshot
- Laceration

Traction Injuries

- Low energy:
  - Not strong enough to cause neurotomesis
  - Usually neuropraxia or low axonotomesis (Sunderland I-III)
  - Possible microvascular injury secondary to stretch
  - Recovery possible
Traction Injuries

- High energy:
  - High axonotomesis and neurotomesis
  - Sunderland (IV-V)
  - Mechanism dependent
    - Neck angle widening
    - Scapulohumeral widening
  - Anatomic dependent
    - Tissues holding roots stronger in C5-6
    - Root avulsions in lower (weaker) and stretch/rupture in upper (stronger) roots
  - May have multiple levels and degrees of injury

Assess the Patient – Thorough Exam

- Test all the muscles of the upper extremity

<table>
<thead>
<tr>
<th>Medical Research Council Grade</th>
<th>Muscle Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No contraction</td>
</tr>
<tr>
<td>1</td>
<td>Weakness or trace of contraction</td>
</tr>
<tr>
<td>2</td>
<td>Active movement, held partly abducted</td>
</tr>
<tr>
<td>3</td>
<td>Active movement against gravity</td>
</tr>
<tr>
<td>4</td>
<td>Active movement against gravity and resistance</td>
</tr>
<tr>
<td>5</td>
<td>Normal power</td>
</tr>
</tbody>
</table>


Assess the Injury – Root Avulsion?

- CT myelogram to evaluate for nerve root avulsions
- There is no chance of recovery with root avulsions
Treatment Guidelines

• Non-operative
  – Observation alone
  – Indicated for most traumatic BPI, including GSW without vascular injury

• Immediate exploration
  – Sharp penetrating trauma, excluding GSW
  – Open injury
  – Vascular injury/expanding hematoma
  – Progressive neurologic deficits

• Early surgical intervention (3-6 weeks)
  – Total or near total BPI with high energy mechanism

• Late surgical intervention (3-6 months)
  – Plateau in neurologic recovery

Surgical Indications (in general)

• Sharp laceration
• No improvement after 6 months non-operative treatment - clinical or electrophysiology findings
• Pediatric
• Postganglionic lesion

Surgical Contraindications (in general)

• Greater than two root avulsions
• Absolute Contraindications
  – Unrealistic goals
  – Refusal of surgery or post-operative plan
• Relative Contraindications
  – Current on-going recovery
  – Stiffness, contractures
  – Age
  – Spinal cord injury
  – TBI
Goals of Treatment

1. Elbow Flexion
2. Shoulder Stabilization
3. External Rotation
4. Shoulder Abduction
5. Wrist and Digital Motion
6. Sensation Distal to Elbow

* Therapy is initiated immediately to maintain motion

Repair Options

- Nerve Grafting *Time factor
- Nerve Transfer – the coaptation of an expendable nerve to the distal end of an injured nerve
- Tendon transfer – the replacement of a lost neuromuscular unit with another neuromuscular unit of less importance
- Arthrodesis
- Free muscle transfer

Case Study

57 yo woman who was stabbed in the neck by a patient while working as a greeter at Sharon Regional Hospital Emergency Room. She was taken immediately to OR for a thyrocervical trunk exploration. She returned to the OR with continued bleeding and her vertebral artery was ligated. She transferred to AGH and was noted to have left arm paresis.
Case Study

15 cm incision anterior left neck and left chest
Motor
• 0/5 left deltoid (axillary nerve)
• 0/5 left biceps (musculocutaneous nerve)
• 0/5 left supraspinatus, infraspinatus (suprascapular nerve)
• 5/5 wrist flexors
• 4/5 wrist extensors.
• 5/5 left triceps
Sensory
• decreased at the C6 sensory distribution.
2+ radial pulse

Summary: Upper trunk injury with deficits of deltoid, rotator cuff and biceps.

Another patient with similar injury but he has some biceps function (1/5)
Intra-operative

Vascular clip proximal and suture on distal part of upper trunk

Intra-operative

1-2 cm gap of upper trunk

Sural Cable Grafts
Grafting of Upper Trunk

Follow-up

4 months
- Good passive ROM
- No motor to proximal muscles (biceps, deltid, cuff)

8 months
- No motor to rotator cuff, deltoid, biceps
- Plan for nerve transfers
- NCS/EMG - no return of function

Surgical Plan

Double fascicular transfer (MacKinnon)
- Ulnar branch to FCU to brachialis branch
- Median branch to FDS to biceps branch of musculocutaneous
- Median sensory to lateral antebrachial cutaneous

Radial to axillary (deltoid) nerve transfer
- Medial triceps branch to axillary nerve
- Radial sensory to axillary sensory

Spinal accessory (trapezius) to suprascapular nerve
Double Fascicular Nerve Transfer

- FCU fascicles of ulnar n to biceps br of musculocutaneous n
- FCR/FDS fascicles of median n to brachialis br of musculocutaneous n

Double Fascicular Nerve Transfer

FCU and FDS Donor Fascicles
Double Fascicular Nerve Transfer

- FCU to Brachialis
- FDS to Biceps
- Median to LABC
- Median N
- Ulnar N

Medial Triceps to Axillary Nerve

Medial Triceps Donor Branch
Medial Triceps to Axillary Transfer

- Radial to axillary motor
- Radial to axillary sensory

SAN to SSN Nerve Transfer

Upper Trunk Injury:
- Lack of shoulder external rotation and abduction
- Lack of shoulder flexion and extension
- Loss of elbow flexion

SAN to SSN tx

Figure 2: Posterolateral approach to spinal accessory to suprascapular nerve transfer.

(Shin JAAOS 2005)
Follow-up

• 6 mos started to have biceps flicker
• 9 mos some deltoid function
• No rotator cuff function

• We planned on latissimus dorsi tendon transfer to restore external rotation
Case Study

31 yo gentleman who struck a telephone pole while riding a dirt bike.

On exam he has a completely flail right arm with no shoulder, elbow or hand function as well as no sensation.

It was almost a year since his injury when I first met him because his outside physicians were just telling him to wait.

I ordered a CT myelogram and it showed he had root avulsion injuries of C6, C7, C8 and T1. C5 was not root avulsed.

Plan:

C5 was still intact but he had no deltoid or cuff function so this meant it was a postganglionic injury, but the C5 root could be a source of axons. We could nerve graft from C5 to the suprascapular nerve.

Free gracilis muscle to restore elbow flexion and finger flexion. We would use the spinal accessory nerve to power it.

You need the triceps to balance the elbow flexion so we would use intercostals to get elbow extension.

(Siqueira Operative Neurosurgery 2010)
Case Study

FIGURE A: A right low grade neurovascular, residual primary tumor, and direct deposits in the tumor metastasis, pseudocapsule and bone, followed by surgery, resection, and cryosurgery. (Giuffra JHS 2010) [Dui JBJS 2013]

Pre-Operative

Intra-Operative

* another patient
“For someone who has nothing, a little is a lot”
- Sterling Bunnell, M.D.

Thank You!
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