Adult Brachial Plexus Injuries: Introduction and the Role of Surgery

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Canniesburn Plastic Surgery Unit, Glasgow Royal Infirmary.

www.brachialplexus.scot.nhs.uk
Brachial Plexus Service

- Started 1997

- Designated National Service for Scotland since April 2004

- **Diagnosis** – Clinical, MRI, Neurophysiology

- **Surgery:**
  - Early nerve repair
  - Secondary reconstruction

- **Rehabilitation:** Multidisciplinary approach, Clinical nurse specialist, Physiotherapy, Occupational therapy.
Referrals and Operations since 1997

- **Referrals**
- **Surgical Explorations for Injury**
- **Operations for Brachial Plexus Tumours**
Proportion requiring nerve exploration, secondary reconstructive surgery, and tumour cases – 937 cases seen since 1997:

- No Operation: 66%
- Nerve Operation: 19%
- Nerve and Secondary Operation: 4%
- Secondary Operation only: 4%
- Tumours: 7%
Guidelines on management and transfer of Brachial Plexus Injury

Victoria Infirmary, Acute Services Division, NHS Greater Glasgow and Clyde

We welcome referral of any acute trauma patient with a brachial plexus injury. We can also advise on any peripheral nerve injury and admit as necessary. All patients must be assessed by local trauma team.

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ASSESS

Assess

Risk factors and associations for Brachial Plexus Injury
- High velocity RTA, especially motorcycles.
- Fracture or dislocation of shoulder, scapula, or elbow.
- Open/piercing injury to neck, upper quadrant of chest, or arm.
- Aerial injury in upper limb.
- Traction injury to the upper limb.

Signs of Injury
- Swelling above and/or below the clavicle.
- Horner's sign.
- Sensory loss in the upper limb.
- Paralysis.
- Sensory loss.

Investigations
Mandatory: Radiographs - Chest, C-spine.
Optional: MRI of the C-spine or CT-myelography. Both are useful in diagnosing root avulsion although neither is 100% accurate. MRI is easier to perform safely after injury.
Neurophysiology is not usually helpful in the acute situation.

Refrerral Centre - Glasgow
Mr T. Hartford Tel: 0141 201 5436
Mr A. Hart (Plastic Surgeon)
(Department of Orthopaedic Surgery, Victoria Infirmary, Glasgow G42)

Local coordinators
Highland
Mr C. McElduff Tel: 01349 880999

Aberdeenshire
Mr A. Johnson Tel: 01224 535747

Lothian
Mr C. Culler Tel: 0131 242 3492

Tayside
Mr J. Smith Tel: 01382 660011

Angus and Stirlingshire
Mr C. McElduff Tel: 01563 527846

Argyll and Clyde
Mr S. Beaumont Tel: 01475 647377

Obstetric Brachial Plexus Palsy
Referrals are welcomed to Department of Orthopaedic Surgery, Royal Hospital for Sick Children, Turriff Road, Glasgow (Mr Derek Stroud and Mr Tim Hems, Mr A. Hart, Miss C. Murray).

Injuries to the Lumbo-sacral Plexus
Indications for referral
- Open injuries.
- Closed injuries: After 3 months - Complete absence of function in the femoral nerve or the tibial division of the sciatic nerve.

Complex upper limb trauma

Motor assessment

- SCAPULAR nerve (C5-C6)
- AXILLARY nerve (C5-C6)
- ERector Muscle nerve (C5-C6)
- RADIAL nerve (C5-C6)
- ULNAR nerve (C7-C8)

Sensory areas

REVIEW AND TRANSFER

Complete a referral form

Think: Vessel...Nerve...Bone

Visit: www.brachialplexus.scot.nhs.uk
Anatomy of the Brachial Plexus
Nerves of the Upper Limb –

Motor Assessment
Anatomy of the Brachial Plexus II

Myotomes

- Shoulder abduction/external rotation C5
- Elbow flexion C5,6
- Elbow extension C7,8
- Wrist flexion/extension C6,7
- Finger flexion C7,8,T1
- Small muscles of the hand C8,T1
Muscle Charting

<table>
<thead>
<tr>
<th>Active movements:</th>
<th>MRC grade (0-5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoulder external rotation (Infraspinatus)</td>
<td></td>
</tr>
<tr>
<td>Shoulder abduction (Deltoid)</td>
<td></td>
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<tr>
<td>Shoulder adduction (Pectoralis major)</td>
<td></td>
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<tr>
<td>Elbow flexion (Biceps)</td>
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<tr>
<td>Elbow extension (Triceps)</td>
<td></td>
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<tr>
<td>Wrist extension</td>
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<tr>
<td>Finger flexion</td>
<td></td>
</tr>
<tr>
<td>Thumb abduction (Thenar muscles)</td>
<td></td>
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<tr>
<td>Finger adduction (Intrinsic muscles)</td>
<td></td>
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</tbody>
</table>

Motor assessment

- **SHOULDER**
  - External Rotation - Suprascapular nerve (C5)
  - Abduction - Axillary nerve (C5)
  - Adduction - Pectoral nerves (C5, 6, 7, 8)

- **ELBOW**
  - Flexion - Musculocutaneous nerve (C5, 6)
  - Extension - Radial nerve (C6, 7, 8)

- **WRIST**
  - Extension - Radial nerve

- **THUMB**
  - Abduction - Median nerve (C8, T1)
  - Adduction - Ulnar nerve (T1)
  - Flexion - Median (and Ulnar) nerve(s) (C7, 8)

- **FINGERS**
Sensory mapping

Sensory areas

<table>
<thead>
<tr>
<th>Sensory assessment</th>
<th>C5</th>
<th>C6</th>
<th>C7</th>
<th>C8</th>
<th>T1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dermatome chart:</td>
<td></td>
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<tr>
<td>Sensation: Normal</td>
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<tr>
<td>Altered</td>
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<tr>
<td>Absent</td>
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</table>
Mechanism of Injury to the Brachial Plexus

- Laceration
- Traction / Stretch – High or low energy.
- Tumour
- Radiation
Grades of Injury to the Brachial Plexus

- Neurapraxia: Recovery likely
- Axonotmesis: Recovery possible
- Neurotmesis: Surgical repair possible
- Postganglionic tear
- Preganglionic tear

Surgical repair impossible
Classification of Brachial Plexus Injury

Supraclavicular

- Affects a combinations of roots.

Infraclavicular
Classification of Brachial Plexus Injury

Supraclavicular

- Usually high energy trauma.
- Violent separation of neck and shoulder girdle.
- C5,6,(7) – Hand function preserved
- Total plexus
- C8,T1 – Upper roots preserved

Infraclavicular
Infraclavicular Injuries

- Often associated with fracture or dislocation at the shoulder or humerus.

- Shoulder girdle muscles preserved.
  - Pectoralis major / Latissimus dorsi

- Pattern of injury
  - One or more terminal branches, eg. Axillary and ulnar n.

- Often don’t require surgery
Investigations:

- **Arteriography** – If evidence of arterial injury.
- **MRI C-spine** - Evidence of pre-ganglionic injury
- **Neurophysiology**
Investigations:

- **Arteriography** – If evidence of arterial injury.

- **MRI C-spine** - Evidence of pre-ganglionic injury

- **Neurophysiology**
Investigations:

- **Neurophysiology** - Not useful in the first 2-3 weeks.
Brachial Plexus Injuries
Surgical Options

• Early exploration of nerves and repair if possible (Within 3 months).

• Late reconstruction: Muscle transfers and bony procedures.
Brachial Plexus Injuries
Indications for Early Nerve Exploration / Repair Surgery

**Within days**
- Open injuries.  
- Associated vascular injury.  
- Ongoing nerve compression.

**Within 3 months**
- High energy injuries with complete loss of function of any part of the plexus.
- Patient fit for operation.
Define the injury:

- Are nerve roots avulsed from the spinal cord?
- Are nerves divided / ruptured?
- Are there lesions in continuity?

Carry out repairs as far as possible.
Brachial Plexus Exploration

Exposure:

• Supraclavicular
• Infraclavicular

Investigations:

• Nerve stimulation
• Sensory Evoked Potentials (SEP)
• Nerve Action Potentials (NAP)
• Frozen section histology
Brachial Plexus Injuries
Objectives of Early Nerve Repair Surgery

- **Shoulder:**
  - Elevation
  - Stability
  - External rotation

- **Elbow:**
  - Flexion

- **Forearm/Hand:**
  - Useful recovery unlikely after nerve repair for supraclavicular injuries.
  - Limited for infraclavicular injuries.
Brachial Plexus Injuries
Objectives of Early Nerve Repair Surgery

- **Partial Injuries**: Hand function preserved
  Useful functional gain possible

- **Complete Injuries**: Limited gain
  Longer term improvement in pain
Brachial Plexus Injuries
Treatment

Options for repair at Operation:

- Lesion-in-continuity - ?**Neurolysis**.

- Nerve ruptures - Excise back to healthy tissue and then **nerve grafts**.

- Root avulsions - a) **Nerve transfers**, Eg. Accessory to suprascapular, Intercostals, Medial pectoral to biceps.
  b) Root replantation - experimental.
Nerve Repair

• Direct Suture

• **Nerve Graft:** Use of an expendable cutaneous nerve, eg. Sural, to repair a damaged segment of an important nerve.
Nerve Transfers

Connection of an expendable nerve to a more important nerve.

• Accessory to suprascapular transfer
Nerve Transfers

Trend in Brachial Plexus Repair

- Accessory to suprascapular transfer
- Triceps n to axillary n \((\text{Leechavenggvongs})\)
- Ulnar to biceps \((\text{Oberlin})\)
- Medial pectoral to Musculocutaneous
- Thoracodorsal to Musculocutaneous \((\text{Novak})\)
- Intercostal nn
- Phrenic n
- Contralateral C7
Advantages of Nerve Transfers:

- Provide an additional source of neurotisation

- Reconstruction possible in cases of root avulsion, eg. Intercostal transfers.

- Contributes to principle of different sources of neurotisation to restore each function.

- Repair in closer to the target muscle => Earlier reinnervation / Later operation.
Reconstruction for Shoulder Paralysis

Nerve grafts:

• 1997 to 2006
• 15 cases nerve grafts for suprascapular n
• 14 also had nerve graft for axillary n
• 7/15 Good or Fair results (PNI unit scale)
• 3/15 Good (2 patients had repair for laceration)
• Only 1 patient had >90° abduction
• 12/15 gained good result from nerve graft for elbow flexion

PNI unit scale: (Birch)
Good: Restoration of functional active movement in at least one axis of a joint.
Fair: Nerve regeneration proven by clinical and neurophysiological examination but of little functional worth.
Poor: No regeneration.
Reconstruction for Shoulder Paralysis

Nerve Transfer:

- Accessory to suprascapular transfer.

- 2001 – 2013
- 20 patients.
- Mean age = 25 (14 – 60)

- 18 also had repair for Axillary n

- 16 patients have sufficient F/U

Nerve Transfers for Shoulder Paralysis

Results

- 13 Good
- 1 Fair
- 2 Poor

- 6 have >90° abduction
- 3 have >150° abduction
- 3 cases <90° abd have grade 3 external rotation.

- Similar trend – *Terzis and Kostas 2006*

Brachial Plexus Injuries

Early Reconstruction of Elbow Flexion

**Supraclavicular**
- Nerve grafts
  - C5/6 → Musculocutaneous n
  - Good results if roots intact
- Nerve Transfers
  - Medial pectoral n (C8) → Musculocutaneous n
  - Ulnar to Biceps n

**Infraclavicular**
- Nerve graft repair of rupture
Reconstruction for Elbow Flexion

Nerve grafts:
  • 27 cases
  • 23/27 good results (MRC >/= 3)
Reconstruction for Elbow Flexion

Nerve transfers:
Medial pectoral to Musculocutaneous
(Brandt and MacKinnon, 1993)

- C5,6(7) injuries
- Deltopectoral approach
- Medial pectoral nerve dissected distally.
- Divided and sutured to M-C n
Reconstruction for Elbow Flexion

**Nerve transfers:**
Medial pectoral → Musculocutaneous

- 12 cases performed. 11 have F/U.

MRC grade 4  9 patients (7/9 > 3 Kg)
  grade 3  1 patient
  grade 2  1 patient

- 10/11 good power in remaining pect major.
C5/C6 Lesion

Medial Pectoral to Musculocutaneous nerve transfer.

Result at 18 month
## Results in 114 repairs up to March 2017

<table>
<thead>
<tr>
<th></th>
<th>Partial plexus injuries</th>
<th>Complete plexus injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients undergoing nerve repairs.</td>
<td>86</td>
<td>28</td>
</tr>
<tr>
<td>Useful gain in function (e.g. Elbow flexion).</td>
<td>66</td>
<td>13</td>
</tr>
<tr>
<td>Failed to attend for follow-up/deceased.</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Too early to assess result.</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Arm Amputation (Severe combined injuries)</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Failure.</td>
<td>4</td>
<td>9</td>
</tr>
</tbody>
</table>
Summary

- Early nerve reconstruction provides useful function for shoulder and elbow.
- Nerve transfers have broadened reconstructive options.
Nerve Injuries in the Upper limb

Further Reading


• Peripheral Nerve Injuries and Repair. In: Surgical Orthopaedics and Traumatology, G Bentley (Ed) 2014, Chapter 82.


• GMS Living Textbook of Hand Surgery, 2016.

• www.brachialplexus.scot.nhs.uk