Nerve Transfer
Nerve Transfer

• Neurotization or Nerve crossing
• Repair of distal denervated nerve element using a proximal foreign nerve as the donor of neurons and their axons, which will reinnervate the distal targets.
Indication

• Brachial plexus roots avulsion
• Proximal injury with a long distance to target muscle
• Significant vascular and bony injury in the region of brachial plexus
• Delayed presentation >6mos
• Previous failed repair
Criteria of donor nerve

• Close to motor end plate of the target muscle
• Expandable or redundant
• Enough pure motor or sensory axons
• Synergistic action to the target muscle
• Size match between the donor and recipient
Advantages

• Donor nerve closer to the end organ, Earlier reinnervation
• Most without interposition nerve graft
• Sometime it’s the only choice

“time is muscle”

----By 2 years, muscle fibers fragmentation and disintegration are complete, with eventual replaced by fat cells.
Disadvantage

• Donor site morbidity - phrenic N, CC7
• No longer suitable for muscle transfer
  - thoracodorsal N (latissimus dorsi),
  - medial pectoral N (pectoralis major)
• Need for central re-education - >3 ys
• Take surgeon away from BP injury site
Categories

Three major categories:
• Extraplexal nerve transfer
• Intraplexal nerve transfer
• End-to-side nerve transfer
Extraplexal nerve transfer

- Phrenic N
- Spinal accessory
- Intercostal N
- Deep cervical motor branch
- Hypoglossal N
- Contralateral C7
Intraplexal nerve transfer

- Proximal stumps C5,6 to lower trunk or median N
- Obline: portion of ulnar nerve transfer to musculocutaneous N
- Anterior thoracic N
- Long thoracic N
- Thoracodorsal N
- Median nerve fascicle
End-to-side nerve transfer

• Distal stump of an irreparably injured nerve implanted into a healthy nerve without injury the function of the healthy nerve
• Mostly used for sensory neurotization
<table>
<thead>
<tr>
<th>Donor nerve</th>
<th>No. axons</th>
</tr>
</thead>
<tbody>
<tr>
<td>C7</td>
<td>23,781 (mean, 16,000–40,000)</td>
</tr>
<tr>
<td>Hypoglossal</td>
<td>5000–6000</td>
</tr>
<tr>
<td>Phrenic</td>
<td>1756 (mean, ?800)</td>
</tr>
<tr>
<td>Spinal accessory</td>
<td>1500–1700 (or 2145)</td>
</tr>
<tr>
<td>Part of ulnar</td>
<td>1600</td>
</tr>
<tr>
<td>Long thoracic</td>
<td>1600–1800</td>
</tr>
<tr>
<td>One intercostal</td>
<td>800–1300</td>
</tr>
<tr>
<td>Deep cervical</td>
<td>893 (? 3400–4000)</td>
</tr>
<tr>
<td>motor branches</td>
<td></td>
</tr>
<tr>
<td>Rami to the pectoral muscle</td>
<td>400–600/ramus</td>
</tr>
</tbody>
</table>
• Clinic examination
• Electromyographic (EMG)
• Intraoperative stimulation

Accurate assessment donor nerve before selecting is very important
Spinal accessory N

- Good source of motor axon: 1,600
- Usually transfer to
  a) Suprascapular N
  b) Musculocutaneous N
SAN to suprascapular N

- suprascapular N repaired alone, 30-90 ° shoulder abduction
- Combined with axillary N repair up to 70-160°
SAN to suprascapular N

- Anterior supraclavicular
- Posterior approach
- Near to the target M avoid SAN injury at superior scapular notch
- Particularly convenient combined with triceps branch to axillary N
SAN to musculocutaneous N

- Result for elbow flexion is good 65-83%, MCR>=grade 3
- Require an interposed nerve graft
- Some author even find that SAN achieve better result than ICNs
Intercostal nerves

- ICNs are mixed motor/sensory nerves
- 500-700 myelinate motor axons
- Standard technique: third to fifth ICNs — MC
ICNs to MC

• Without nerve graft: 70-80% good result
• With nerve graft: 47% M3 or better result
• Doesn’t impair respiratory function
Phrenic nerve

- Originate from C3-C5, mainly from C4
- when brachial plexus injury, 20% impaired
- Predominance of motor nerve
  - 1,600-1,800 axons
- Easy to find and dissect
  - on the surface of anterior scalene
• Short length of nerve available
• Harvest phrenic N thoracoscopically
• Result of transfer to musculocutaneous
  80-90% MRC 3
  more than 50% MRC 4
Complication of phrenic N

- Respiratory function compromise
- Adult: 10% decrease in vital capacity; recover in 1 year
- Infant and child: severely detriment
  research confirm that respiratory dysfunction in the long term because impede lung development
• Children, especially less than 3 ys
• Poor cardiorespiratory function
• Multiple fibs fx
• Obesity

Should avoid phrenic nerve transfer
Contralateral C7

- Rich source of nerve fiber (23,000 axons)
- Gu introduced CC7 in 1986
- Hemi-CC7 (anterior or posterior division)
- 2002 McGuiness and Key reported prespinal route
- Beijing Jishuitan Hospital prespinal route and directly suture to lower trunk
Result

• About 50% approaching MCR grade 3 or better result
• Long graft distance
• Results from Mayo clinic is poor
Hemi-Contralateral C7 Transfer in Traumatic Brachial Plexus Injuries: Outcomes and Complications

<table>
<thead>
<tr>
<th>No. of Patients</th>
<th>Shoulder Group (no.)</th>
<th>Median Nerve Group (no.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>13</td>
<td>15</td>
</tr>
<tr>
<td>EMG evidence of reinnervation†</td>
<td>12†</td>
<td>3</td>
</tr>
<tr>
<td>Motor grade‡</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M0</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>M1</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>M2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>M3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>M4</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>M5</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Methods of transfer

• Directly repair
• Sural nerve graft (cable)
• Vascularized ulnar nerve graft

Ⅰ. Pedical type: cross chest
    based on superior upper collateral ulna A

Ⅱ. Free type: cross neck
Directly repair

- Prespinal route
- Trim lower trunk
- Shorten humerus 4cm
- Anterior transfer ulnar nerve at elbow
Complication

• Subjective sensory change within 1 month
• 2PD normal at 2 weeks postoperatively
• Motor weakness in 2 months triceps and extrinsic finger extensor M
• Severe donor side motor deficits is rare
• Facilitatory action of health side at least 3 years
Follow up 22 cases

- Subjective sensory change within 1-2 mos
- Healthy side 2PD normal
- Fingers and elbow extension strength recover within 3-4 mos
- 1 mos post op, Grip strength decrease 18%, 1 year later, grip strength recover completely
• Most, passive movement of fingers, health side still has abnormal sensation (tingling) at contralateral side.
• 3 years follow up
• Contralateral side IF still can’t extend
Medial pectoral N

• Receive input mainly from C7 to C8
• Medial pectoral N transfer to MC
• 68-84% useful result
  (MRC G3 or better)
Ulnar nerve fascicle transfer

• Oberlin, first report, 1994
• Fascicle predominant innervation to FCU
Oberlin procedure

- Reinnervation start as early as 3.3 mos
- 93% recover elbow flexion to MRC G 4
- No patient show hand function deterioration
Double fascicle transfer

- Machinnon, 1997
- Brachialis is the main elbow flexor
- Biceps primarily supinator and flexion secondly function
- Double fascicle transfer in delayed (>6 mos)
- Median N fascicle mainly to FCR or palmaris longus M
Triceps M branch to Axillary N

• Firstly, Long head of triceps branch transferred to anterior division of axillary N
• Later, Medial head is easy to find and length enough
• Regardless of chosen branch, muscle weakness rarely occur
Distal AIO branch

- Pronator quadratus muscle branch
- 900 motor axons
- Transfer to deep motor branch of ulnar nerve
Thoracodorsal N

• Receive input from C6 to C8
• Pure motor nerve
• Myelinated axons 1,500-2,500
• Length for transfer: 12.3 cm
• Transfer to: musculocutaneous N
  axillary N
Median N branch to radial N

**FIGURE 3:** Transfer of expendable FDS and palmaris longus branches of median nerve to ECRB and posterior interosseous nerve branches of radial nerve.
General principles

• Nerve transfer is always superior to muscle or tendon transfer within the early stage (<5mos) in adult brachial plexus injury
• Direct suture without tension superior to N graft
• Ipsilateral nerve transfer superior to contralateral (IC5>CC7)
• Health of donor nerve is an determining factor
• Patients must be motivated and able to cooperate with recommendations (reeducation)
General principles

• Phrenic N — shoulder or E,W,F extensors
• SAN — shoulder abduction
• ICN — elbow flexion
• Obline — elbow flexion (best if available)
• CC7 — fingers flexors and sensation
• Hypoglossal and deep cervical motor branch adjuvant N for shoulder
• All previous N can transfer to function free muscle
Strategy for total BPI

Acute Injury
3-5 months, complete studies

Exploration of brachial plexus

If C5 stump is healthy
- C5-VUNG-MCN and MN + other nerve transfer(s)

If C5 stump is questionable
- C5-ng to the distal C5 and CC7-VUNG-MC and MN + other nerve transfer

If C5 stump is avulsed
- CC7-VUNG-MC and MN + other nerve transfer(s)
  - <18 Months
    - If E-f ≥ M2
      - Advise patient to early accept FMT for finger flexion
    - If E-f (-)
      - Stump revision or shifts to Doi’s double muscles

FIGURE 1: Algorithm for 4- or 5-root avulsion injury of the brachial plexus. ng, nerve graft; MN, median nerve; E-f, elbow flexion; FMT, functioning muscle transplantation; MCN, musculocutaneous nerve; VUNG, vascularized ulnar nerve graft.
Summary

Nerve transfer provide another option for reconstruction of neurologic deficits.

As a primary option, there is evidence of comparable or superior results of nerve transfer for extensive proximal and brachial plexus injury.