Adult Brachial Plexus Injuries: Introduction and the Role of Surgery

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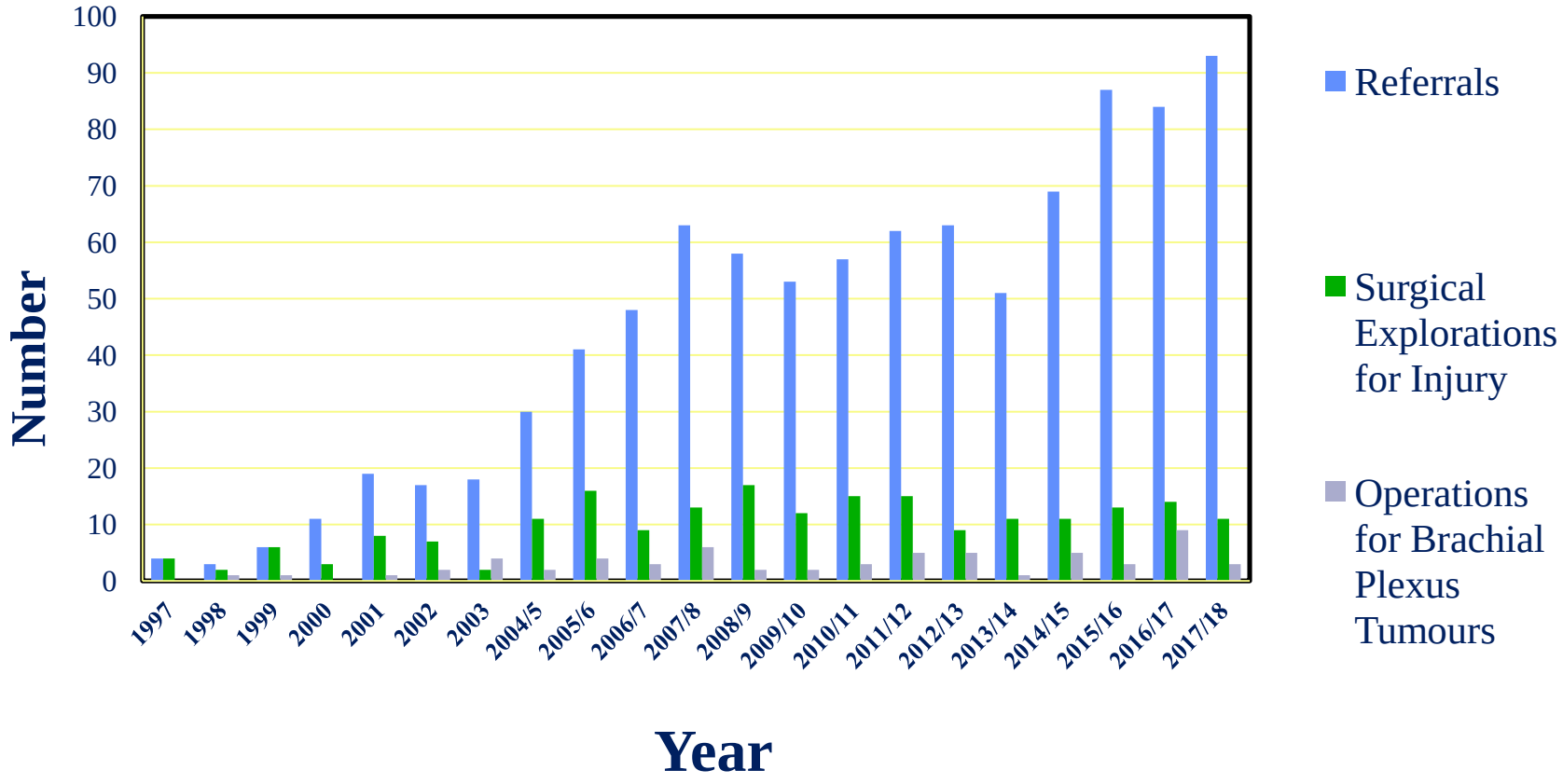
www.brachialplexus.scot.nhs.uk

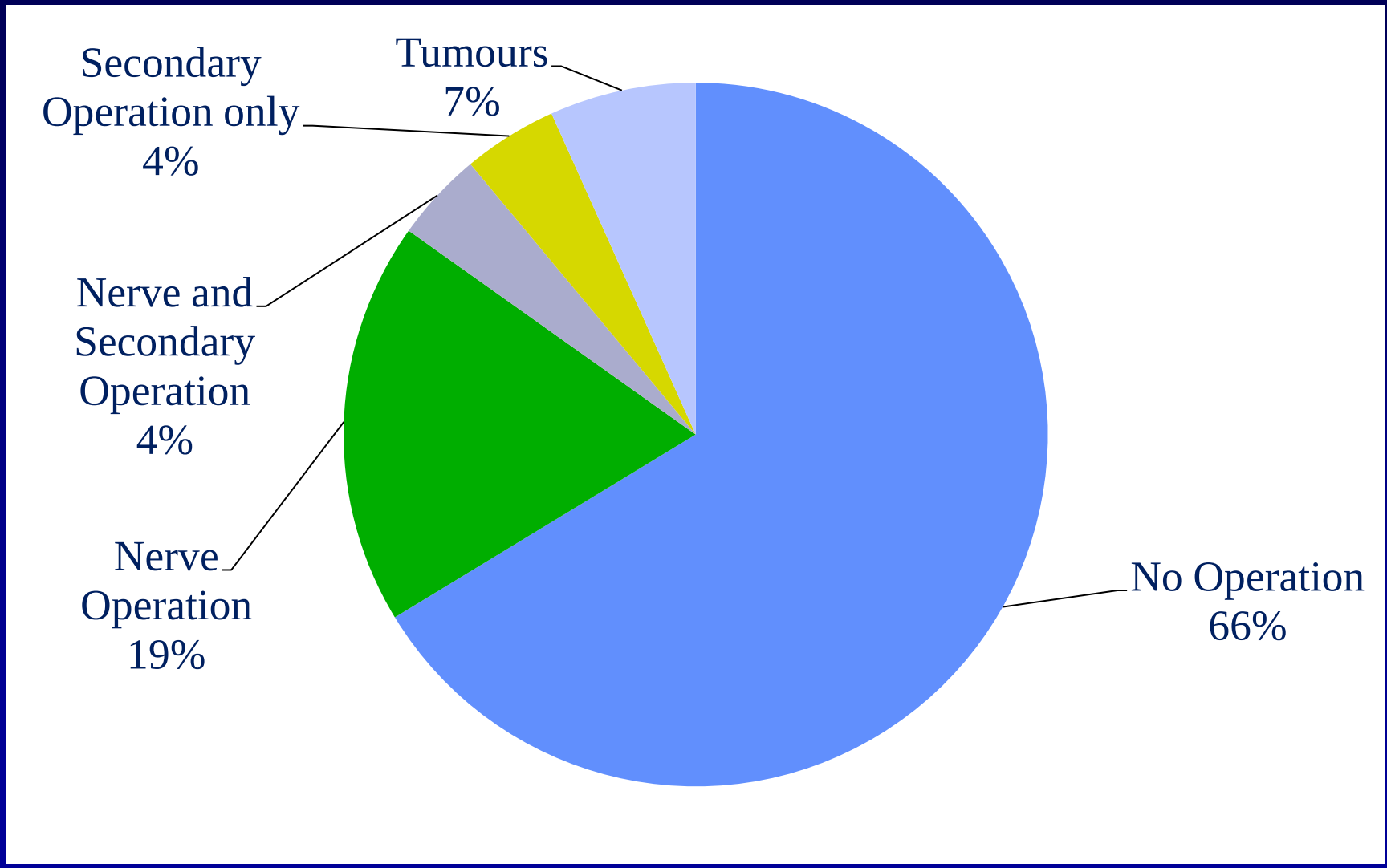
Brachial Plexus Service

- 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.

Brachial plexus service, Glasgow.



Proportion requiring nerve exploration, secondary reconstructive surgery, and tumour cases – 937 cases seen since 1997:



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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.

Tel: 0141 201 5436 (Office hours) OR: 0141 201 6000 Bleep 5440
Fax: 0141 201 5818
Email: brachial.plexus@gvic.scot.nhs.uk
Website: www.brachialplexus.scot.nhs.uk

The Victoria Infirmary
Department of Orthopaedic Surgery
Langside Road
Glasgow G42 9TY

ASSESS

Assess

Acute - resuscitate and stabilise patient.
Airway, Breathing, Circulation.

Risk factors and associations for Brachial Plexus Injury

- High velocity RTA, especially motorbike.
- Fracture or dislocation of shoulder, scapular, or elbow.
- Open/penetrating injury to neck, upper quadrant of trunk, or arm.
- Arterial injury in upper limb.
- Traction injury to the upper limb.

Signs of injury

- Swelling above and/or below the clavicle.
- Horner's sign.
- Severe pain 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 avulsions although neither is 100% accurate. MRI is easier to perform early after injury.

Neurophysiology - Is not usually helpful in the acute situation.

Referral Centre - Glasgow

Mr T. Hems _____Tel. 0141 201 5436
Mr A. Hart (Plastic Surgeon)
(Dept. of Orthopaedic Surgery, Victoria Infirmary, Glasgow G42)

Local coordinators

Highland _____Mr. D.Finlayson (Tel. (0141) 70400)
Aberdeen _____Mr. A. Johnson (Tel. 01224 55675)
Lothian _____Mr. C. Oliver (Tel. 0131 242 3402)
Tayside _____Mr. J. Dent (Tel. 01382 660111)
Ayrshire and Arran _____Mr C. Macleod (Tel. (01563) 577896)
Argyll and Clyde _____Mr S. Barnes (Tel. 01475 633777)

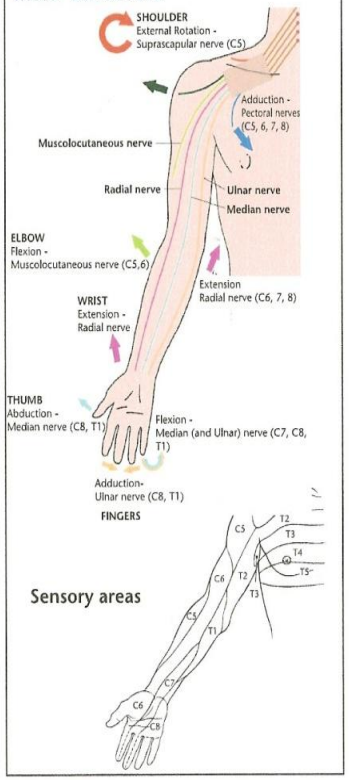
Obstetric Brachial Plexus Palsy

Referrals are welcomed to Department of Orthopaedic Surgery, Royal Hospital for Sick Children, Yorkhill, Glasgow (Mr David Sherlock and Mr Tim Hems, Mr A Hart, Miss C Murnaghan).

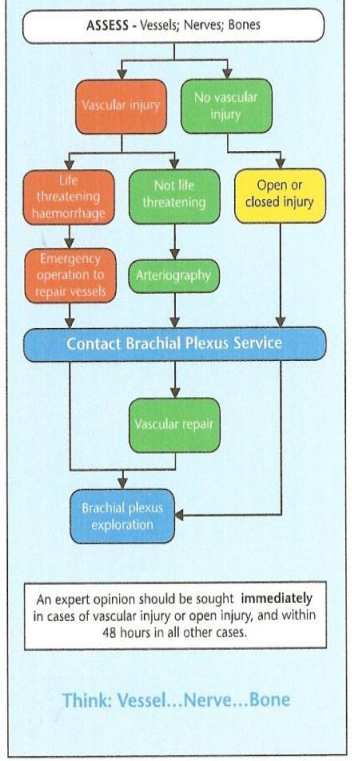
Injuries to the Lumbrosacral Plexus

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.

Motor assessment



Complex upper limb trauma



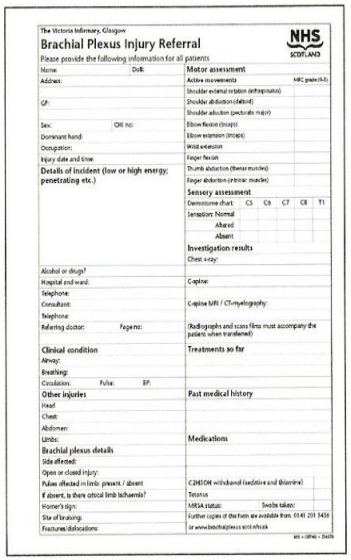
An expert opinion should be sought **immediately** in cases of vascular injury or open injury, and within 48 hours in all other cases.

Think: Vessel...Nerve...Bone

REFER AND TRANSFER

Complete a referral form

Please provide the following information for all patients.



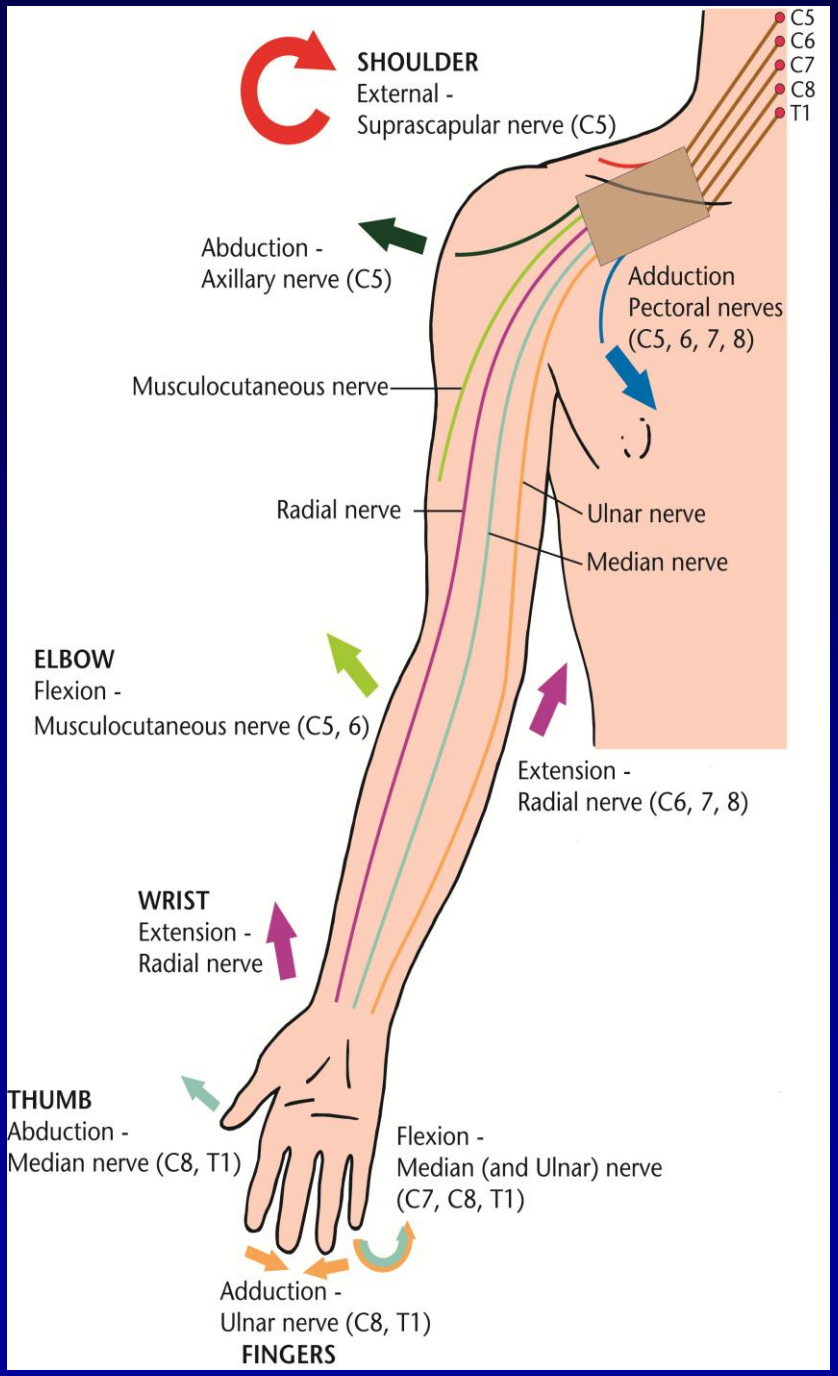
Referral forms can be obtained by telephoning:
0141 201 5436
or can be downloaded as a PDF file from:
www.brachialplexus.scot.nhs.uk

NHS•GRETNO•236580

Anatomy of the Brachial Plexus

Nerves of the Upper Limb –

Motor Assessment



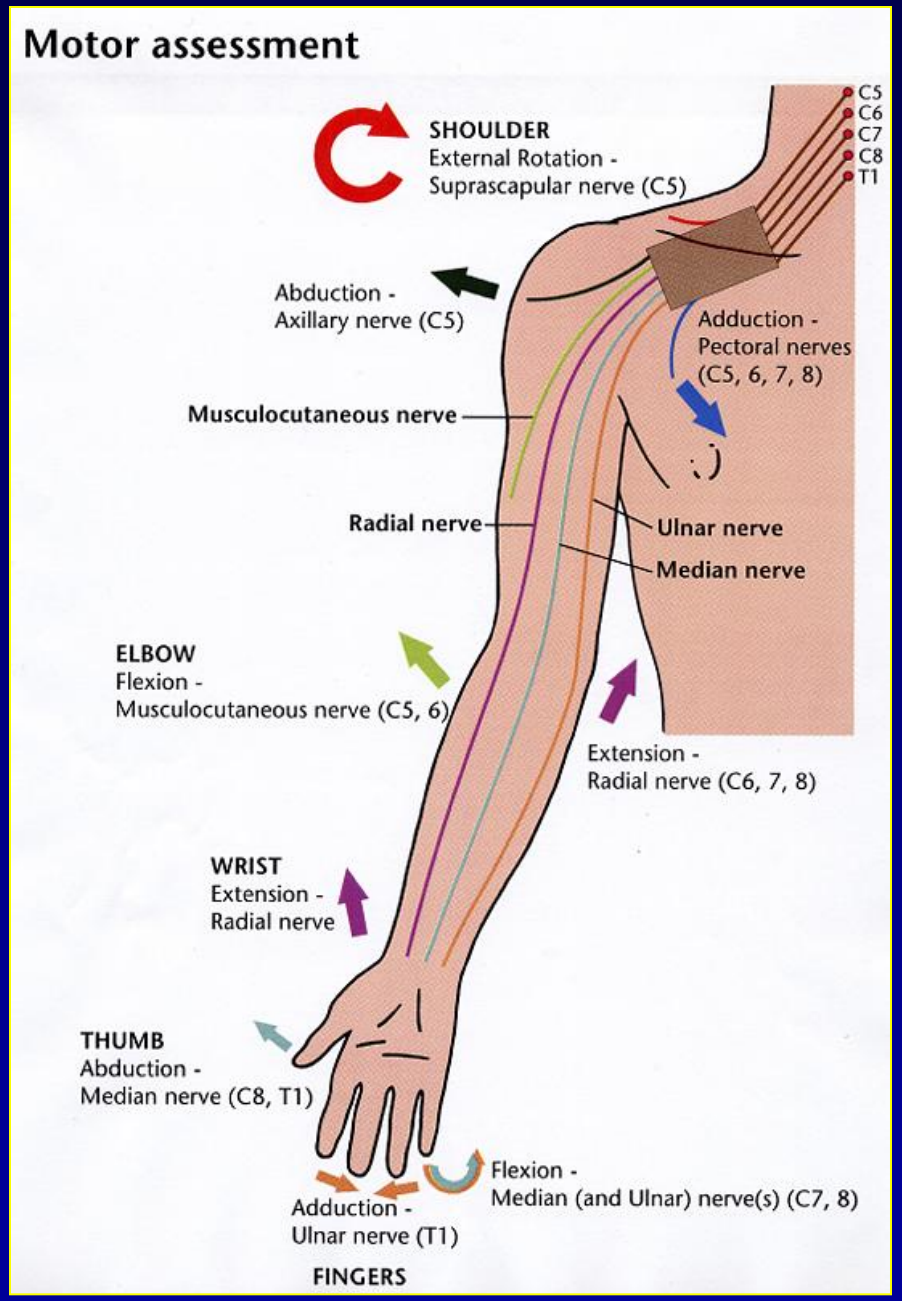
Anatomy of the Brachial Plexus II

Myotomes

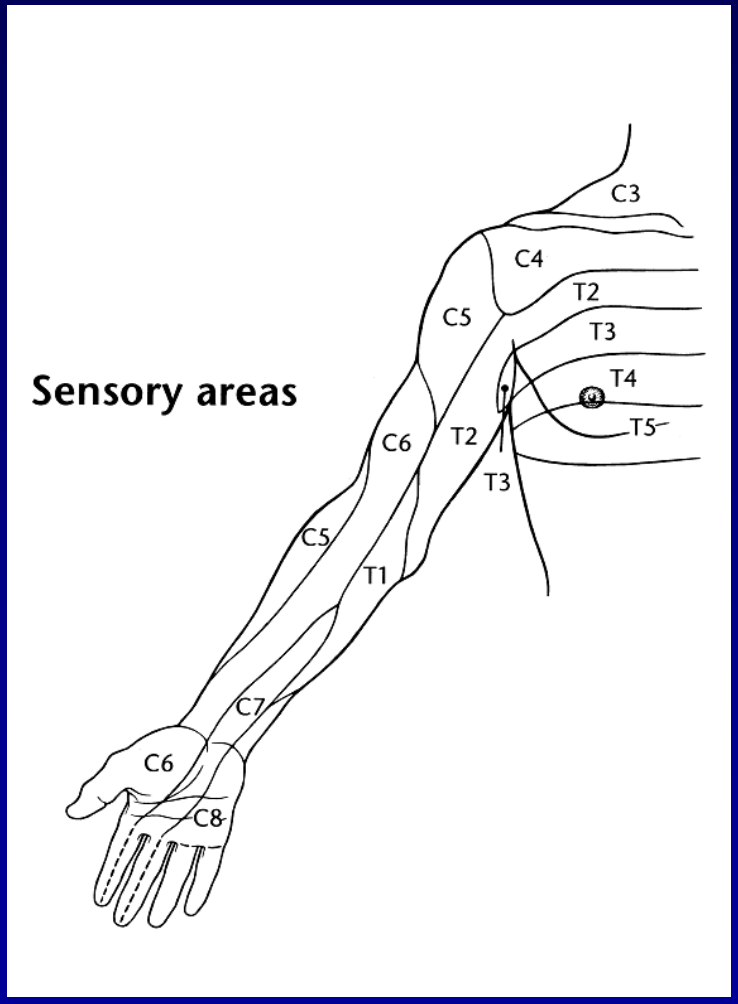
• Shoulder abduction/external rotation	C5
• Elbow flexion	C5,6
• Elbow extension	C7,8
• Wrist flexion/extension	C6,7
• Finger flexion	C7,8,T1
• Small muscles of the hand	C8,T1

Muscle Charting

Active movements:	MRC grade (0-5)
Shoulder external rotation (Infraspinatus)	
Shoulder abduction (Deltoid)	
Shoulder adduction (Pectoralis major)	
Elbow flexion (Biceps)	
Elbow extension (Triceps)	
Wrist extension	
Finger flexion	
Thumb abduction (Thenar muscles)	
Finger adduction (Intrinsic muscles)	



Sensory mapping

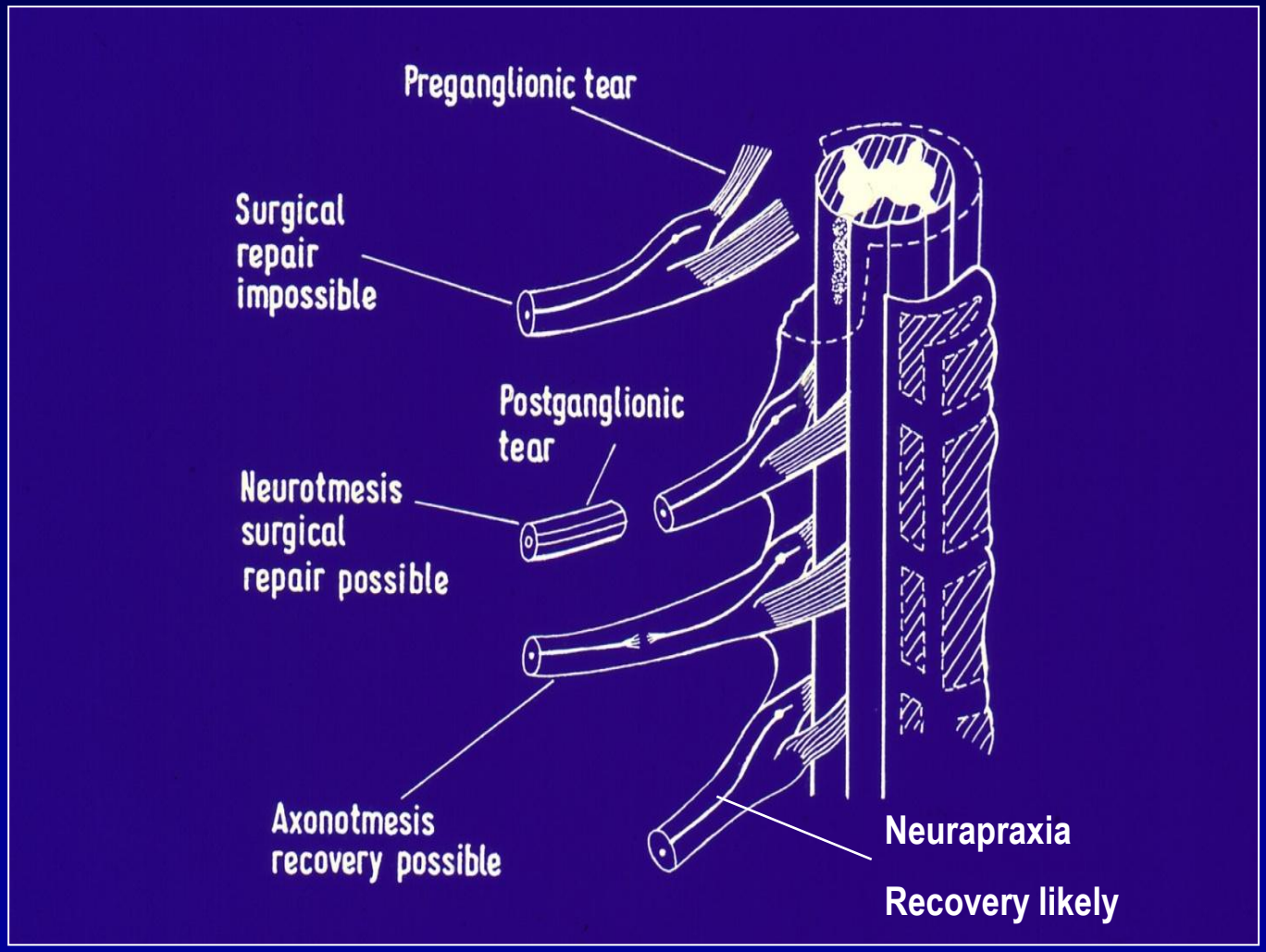


Sensory assessment					
Dermatome chart:	C5	C6	C7	C8	T1
Sensation: Normal					
Altered					
Absent					

Mechanism of Injury to the Brachial Plexus

- Laceration
- Traction / Stretch – High or low energy.
- Tumour
- Radiation

Grades of Injury to the Brachial Plexus



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

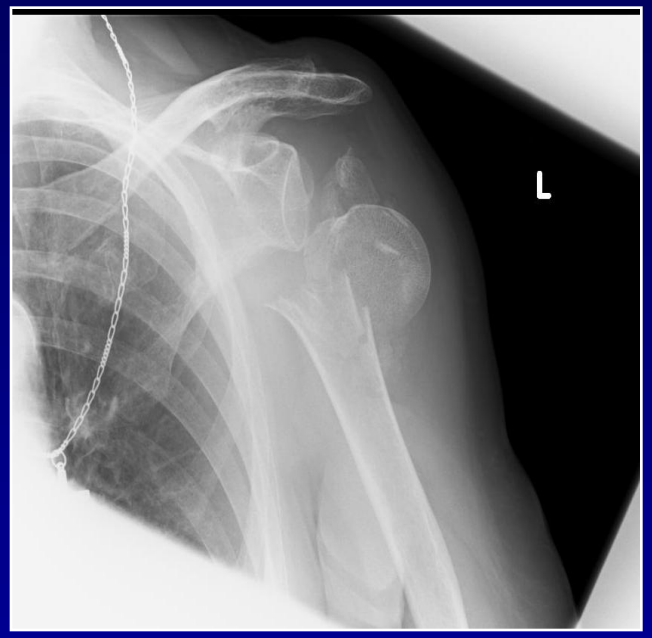
Infraclavicular Injuries

- **Often associated with fracture or disolcation 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.

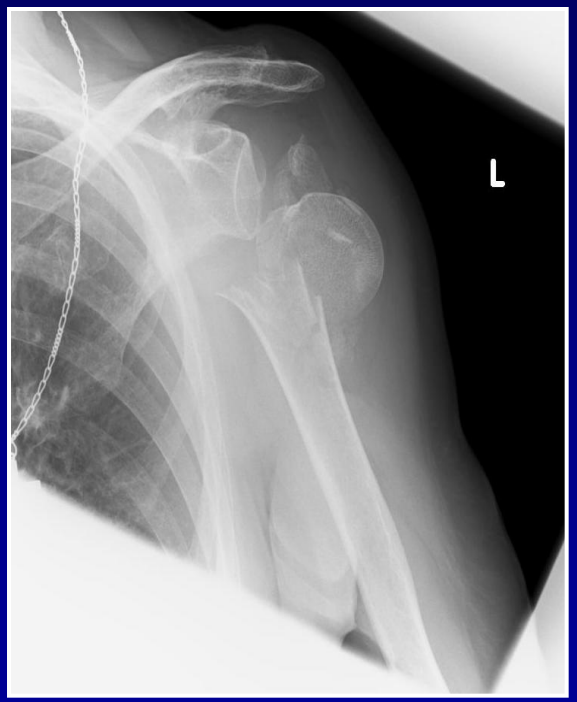
Brachial Plexus Injuries
Surgical Options

- **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.

Brachial Plexus Injuries
Objectives of Early Surgery

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.

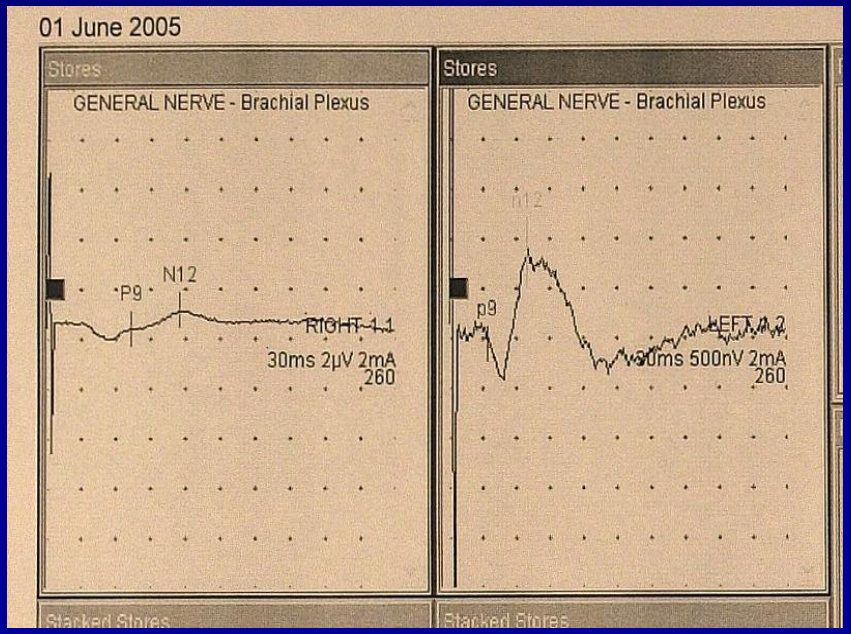
Brachial Plexus Exploration

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 *(Leechavenggvongs)*
- Ulnar to biceps *(Oberlin)*
- Medial pectoral to Musculocutaneous
- Thoracodorsal to Musculocutaneous *(Novak)*
- Intercostal nn
- Phrenic n
- Contralateral C7

Nerve Transfers

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^{o} 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

Hems, T.E.J. (2011). Nerve transfers for traumatic brachial plexus injury. Advantages and problems. *Journal of Hand and Microsurgery, 3,* 6-10.

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*

Terzis, J.K., & Kostas, I. (2006). Suprascapular nerve reconstruction in 118 cases of adult post-traumatic brachial plexus. *Plastic and Reconstructive Surgery, 117*, 617–629.

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

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

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

- Chapter on 'Nerves' in Bailey & Love's Short Practice of Surgery, 24rd Edition, 2004.
- Surgical Disorders of the Peripheral Nerves, by Birch, Springer, 2010.
- Peripheral Nerve Injuries and Repair. In: *Surgical Orthopaedics and Traumatology*, G Bentley (Ed) 2014, Chapter 82.
- Tim Hems. Brachial Plexus Injuries. In Nerves and Nerve Injuries, Volume 2, Edited by: R. Shane Tubbs, Elias Rizk, Mohammadali Shoja, Marios Loukas, Nicholas Barbaro, Robert J. Spinner. Elsevier. 2015, pp.681-706.
- GMS Living Textbook of Hand Surgery, 2016.

http://www.gms-books.de/book/living-textbook-hand-surgery/chapter/nerves

- **www.brachialplexus.scot.nhs.uk**