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Scottish Adult Brachial Plexus Injury Service

Information for Therapists

Scottish Adult Brachial Plexus Injury Service
The Victoria Infirmary
Langside Road, Glasgow G42 9TY
Website: www.brachialplexus.scot.nhs.uk

Introduction

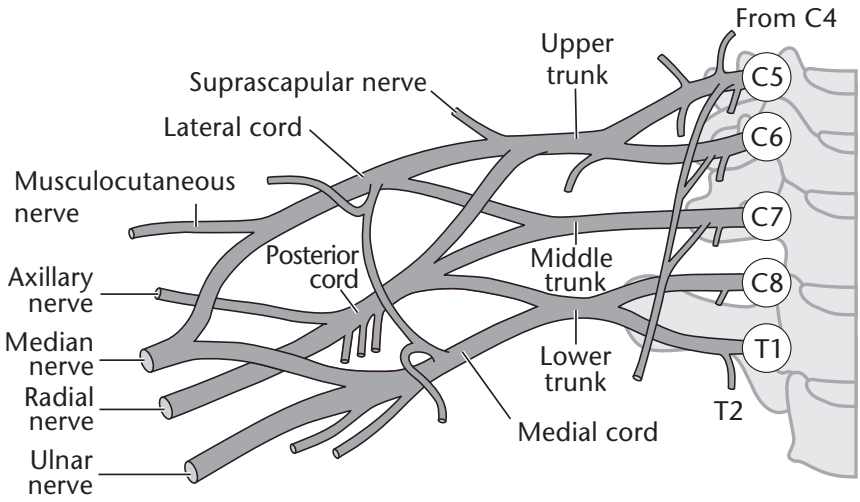
The Scottish Adult Brachial Plexus Service was established in April 2004 to offer specialist treatment for patients with mainly traumatic brachial plexus injuries. The team comprises of orthopaedic and plastic surgeons, nurse, occupational therapist, orthotist and physiotherapist

In the UK, traumatic injuries to the brachial plexus are relatively uncommon. These are complex and disabling injuries and require specialist input. It is essential that they are carefully assessed and managed from the outset.

See the service website for up to date information on the service including referral criteria, forms, contact information, patient and health professional information and education.

www.brachialplexus.scot

Nerves of the Brachial Plexus



Mechanism of injury

- High velocity injury - stretch injury
- Low impact injury - stretch injury
- Lacerations

If the injury was sustained due to a high velocity accident e.g. a motorcycle RTA, then the likelihood of a more serious pathology is much greater than someone who has sustained an injury from a fall. Patients involved in high velocity accidents are also more likely to sustain other injuries e.g. head injuries, spinal and upper limb fractures and vascular damage.

Patients who have sustained a brachial plexus lesion will present with motor and sensory loss in all or part of the upper limb depending on the extent of the injury.

Clinical factors that may indicate a milder lesion less likely to require surgery:

- Low impact
- Incomplete lesion
- No pain
- Tinel's sign
- Absent Horner's sign

Clincal factors indicating a more serious lesion that may require surgical exploration and repair:

- High impact injury
- Complete lesion
- Burning or shooting pains present since the time of injury
- ? Horner's sign (ptosis or drooping of the eyelid with dilation of the pupil)

Damage to the BP can also occur as the result of tumours or as a result of radiation treatment.

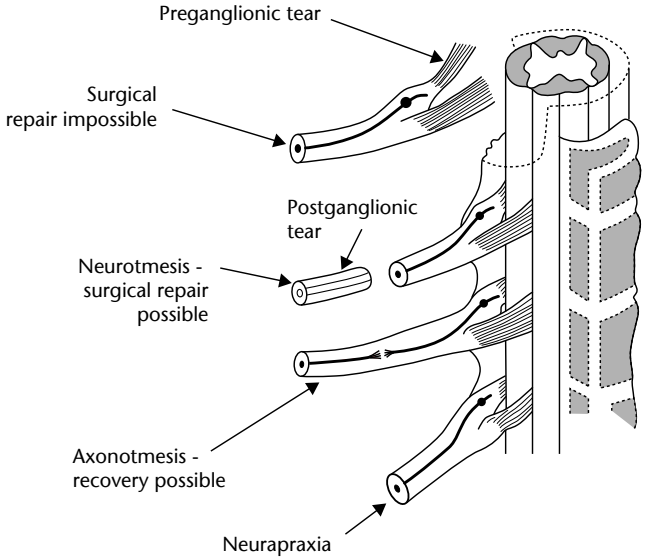
Brachial plexus injuries may occur at the time of birth (Birth Related Brachial Plexus Injury). There is a separate service for children based at the Royal Hospital for Children, Glasgow.

Grades of injury

The damage to the brachial plexus nerves can be classified into four different grades:

1. Pre-ganglionic tear.....Nerve root avulsion
2. Post-ganglionic tear.....Neurotmesis
3. Severe lesion in-continuity....Axonotmesis
4. Mild lesion in-continuity.....Neurapraxia

The number and combination of nerves injured are very variable. It should be noted that some patients can present with a combination of root avulsions, post-ganglionic tears and lesions in-continuity.



Adult brachial plexus injuries fall into two categories:

1. Supraclavicular injuries.....Nerves damaged above the clavicle
2. Infraclavicular injuries.....Nerves damaged below the clavicle

It is possible for nerves to be injured both above and below the clavicle.

Supraclavicular injuries

Supraclavicular injuries can be caused by a traction injury to the brachial plexus e.g. in a motorcycle accident where the head is side flexed and the shoulder girdle is depressed, or through direct trauma e.g. knife injury or gunshot wound.

Common patterns of supraclavicular injury occur and can be subdivided into three groups:

1. Upper plexus C5,6 (+/-C7and +/-C8) If C7 and C8 are involved the roots are sometimes avulsed. There is less likelihood that the roots of C5 and C6 will be avulsed.
2. Total plexus - there is damage to all nerve roots. C5, C6 may have post ganglionic ruptures with the roots of C8 and T1 avulsed.
3. Lower plexus - the roots of C8 and TI are avulsed but C5 and C6 are working normally.

Avulsion injury/Preganglionic injury

A high velocity accident is more likely to cause avulsion of the nerve roots from the spinal cord. If the nerve roots are avulsed in this way, there is no successful method available for re-implanting the rootlets (experimental work is underway). Patients presenting with avulsion injuries usually complain of an instantaneous onset of pain. This is commonly described as a deep burning pain with frequent shocks of shooting pains throughout the day. The pain is caused by deafferentation of the dorsal horn, which means that with no input from the periphery, pain information passes from the dorsal horn to the brain unmodulated.

Apart from the clinical examination, an MRI scan will often help to confirm the diagnosis. From the scan results, the location of the root avulsion can sometimes be seen, as there is the presence of a meningocele (sack filled with CSF leaking from the spinal cord).

Although re-implantation of nerve rootlets is not currently used, other methods of restoring nerve supply can be undertaken, e.g. nerve transfers. This will vary from patient to patient and will depend on the extent of the damage and therefore the feasibility of using unaffected nerves. Commonly used nerves for nerve transfers are the intercostals, accessory nerve and the medial pectoral nerve.

This group of patients will always have some form of long term motor deficit. Secondary operations may be considered - for example fusion of the wrist and muscle transfers to increase finger extension when there is a long term radial nerve deficit.

Infraclavicular injuries

This type of injury can affect any one or all of the peripheral nerves. The most common presentations are:

- A complete lesion
- Damage to axillary nerve
- Damage to musculocutaneous nerve

These injuries are usually caused by excessive tractioning of the brachial plexus e.g. following shoulder dislocation or in conjunction with a fractured humerus.

As with all BPI, assessment including muscle testing, sensation testing and neurophysiology tests help to complete the clinical picture. It is especially important to check with those patients presenting following shoulder dislocation that the disruption of shoulder movement is not caused by a tear in the rotator cuff.

Where there has been a severe infraclavicular injury i.e there has been a high energy injury affecting several peripheral nerves, the surgeon may choose to reconstruct only some of the peripheral nerves. This could be because the gap between the damaged nerve ends is too wide to successfully bridge.

Surgical patient

As with all surgery, before deciding to operate, several factors have to be considered. These include:

- Other injuries if poly-trauma
- Co-morbidities and age
- the patient is strongly encouraged to stop smoking to acheive maximum benefit.

Primary repairs

These are normally carried out as soon as possible and usually within 3 months of injury.

The surgical option include:

- Nerve grafting/reconstruction
- Nerve transfer

Nerve graft/Nerve transfer

Post-operatively patients who undergo nerve grafting and nerve transfers are managed in a similar way.

Patients are normally admitted to the Orthopaedic ward, one day prior to surgery. They will usually have been assessed (see appendix 1) at the Brachial Plexus Clinic pre-operatively. In addition other investigations such as neurophysiology tests and MRI will already have been done.

Patient Rated Outcome Measures for function and pain and are assessed in clinic at regular intervals. These are available on the service website.

When a patient is admitted to the ward the Physiotherapy/Occupational Therapy inpatient staff liaise with the BPI team. A unified approach is important to avoid conflicting information being given to the patient.

Rehabilitation

1-4 weeks post-op

Patients are usually discharged from the ward on Day 2 or 3 post-operatively.

Local outpatient MSK physiotherapy follow up is should be arranged on discharge, this is organised by the inpatient staff. This is organised by the in-patient staff. Once there is confirmation of the arrangements, the information is passed to the BPI team. Operation notes should be attached to referral. If they are not available on discharge, a copy can be obtained from the BPI service adminstrator.

After nerve grafting and nerve transfers, the patients are immobilised in a polysling for 4 to 6 weeks. During this time they are not allowed to move their shoulder, however they should be encouraged to maintain the movements of their wrist and fingers. These restriction only apply if repairs undertaken, <u>there are no restriction pre-operatively and in conservatively managed patients.</u> Please check the operation note for details.

It is possible that patients will have sustained multiple injuries, which will also require rehabilitation. If the patient has been treated at another hospital for other injuries sustained at the time of their BPI then it is usual for that hospital to continue with the review/management of these injuries. The BPI service is specifically funded to treat BPI's only.

4-6 weeks post-op

The patient is normally reviewed at the BPI clinic or (or Canniesburn plastic surgery unit depending on where their surgery took place) before the polysling is removed. However, if the timing does not coincide with the next clinic appointment and the operation notes clearly specify when the sling is to be removed you can go ahead and remove the sling. If in doubt contact a member of the BPI team.

When the sling is initially removed the patient will be apprehensive. Sometimes there is increased pain due to the change in position, so it is important to advise the patient to take their pain medication before treatment.

As one would expect once the sling is removed the patients have restricted passive movements of the upper limb. It is therefore important to start on a passive movement programme (see Appendix 2). If they have any active movements then this should also be started. There are usually no restrictions in what they are allowed to do.

Characteristic limitations of movement

Shoulder joints: ..... Elevation, abduction, lateral rotation

Elbow joints:..... Extension and supination

Wrist joints: ..... Flexion and extension

MCP joints:..... Flexion

PIP joints: ..... Extension

Soft tissue changes

- Reduced web space
- Shortening of the long flexors
- Fibrosis of the intrinsic muscles

If the movements of the shoulder are very restricted it is useful to show a relative how to help with the exercises, particularly lateral rotation and abduction. Once a reasonable passive range has been achieved, the patient can start to combine movements (i.e. elevation/abduction and lateral rotation) and continue their exercise independently. This is an important aspect of the patient's upper limb management.

If the patient is happy to keep the sling off then this should be encouraged. If not, gradually reduce the amount of time that the sling is worn for. Some patients like the comfort of the sling when they go out, or when they are undertaking certain sports and hobbies that is very good to encourage.

Aims of treatment

- Increase/maintain range of movement
- Mobilise tight scar tissue
- Maintain good joint position, especially in the hand, splint if necessary
- Discuss/help with pain control
- Improve posture and balance
- Encourage inclusion of the limb in meaninful activity as much as possible, assist with aids as necessary.
- Maximise function

- Encourage return to work or sport
- Improve muscle power in surviving motor units

Pain

The complexity of tBPI injuries means that levels of pain described in this patient group is highly variable. Neuropathic pain is common from direct nerve trauma. However in tBPI, along with the motor and sensory disturbance is soft tissue oedema, contractures, poor control and stability this can contribute to nociceptive pain and should be addressed directly.

It is important that pain is recorded and monitored accurately and there are several patient rated outcome measures available to assist (see website for the current tools used within the tBPI service).

A combined approach is required as with any musculoskeletal problems to address this by pharmacological, physical, psychosocial means. Local pain services can be utilised along with our Clinical Nurse specialist providing support and counselling. Pain medication is also discussed at clinic appointments and medication recommendations can be conveyed back to primary care.

Sensory rehabiliation techniques such as those described in Graded Motor Imagery Approach (NOI,2024) can also assist with pain management.

Activity and Participation

"The Activity and Participation domain of the WHO-ICF covers a broad spectrum of experiences that one would consider to be everyday functional activities and life roles. These include activities of daily living such as personal care, meal preparation, feeding, socialization, and work. Therefore, the evaluation of function should include a meaningful measurement of the ability of a person to function or operate in their usual way. Patient and clinician reported outcome measures of function aim to gather information about how able an individual is to carry out everyday tasks. The information gained from these can help to monitor progress and prioritize specific treatment goals." Brown et al (2022)

The Occupational Therapy Section of the website has an extensive section on advice and aids to assist with all aspects of ADLs and coping living with limited use of one hand. It is important that patients undertake meaningful activities with their limb as much as possible for neurological and psychological recovery.

One year +

Patients should be starting to show signs of recovery in the nerves that have been reconstructed. Early signs would be a progressive Tinel's sign which would become apparent before other signs of recovery. Once a flicker can be detected in a muscle it is important to intensify treatment again. It may be that patients are shown anti-gravity positions to exercise in, or use muscle stimulators over motor points (see Appendix 1). Sometimes it is hard to convince the patient that the muscle is working as no movement is being produced. Once recovery starts it normally continues to progress. Recovery may continue for 4 to 5 years.

Aim of surgery and expected outcome

The aim of a primary repair is principally to improve motor function. However, primary surgical repair can aim to improve sensory function particularly protective sensation in the hand.

The expectation from primary repair is to achieve elbow flexion. Results in terms of effective shoulder control have so far been mixed.

Hand and wrist function can be improved with primary surgery but if necessary can benefit from secondary operations e.g. tendon transfers and bony fusions.

Secondary operations

Secondary operations fall into two categories:

1. Bony fusions
2. Tendon transfers

Bony fusions will only be considered when there is no chance of further useful recovery.

Tendon transfers

Tendon transfers are considered at a later stage, usually at about two years post injury. Sometimes tendon transfers will be considered before this to aid function while recovery in the nerves takes place.

Tendon transfers are most commonly performed in the hand. However, occasionally free muscle transfers may be used to improve elbow flexion e.g. gracilis.

Patients who present with avulsion of the roots of lower trunk (C8 -T1) only may eventually be appropriate for tendon transfer. In order for this to be successful **it is important to teach the patient how to maintain**

joint range of movement and to maximise the strength in the muscle groups which are still functional. Tendons used for transfer must be a Grade 4 or better. Tendon transfers in the hand must be planned so that pinch and grip will be improved.

Rehabilitation involves the re-education of function, occasionally with trick movements or with the co-ordination of other movements e.g. wrist extension with finger flexion.

Conservatively Managed traumatic BPI

Patients who fit into this category are those who have suffered temporary damage to the conduction of the nerve for example a neurapraxia or an axonotmesis or those with brachial neuritis. These injuries/pathologies can take from several months to over a year to recover and it is therefore essential that the patient understands this and knows the importance of maintaining joint range of movement while waiting for recovery.

Rehabilitation of the non-surgical patient

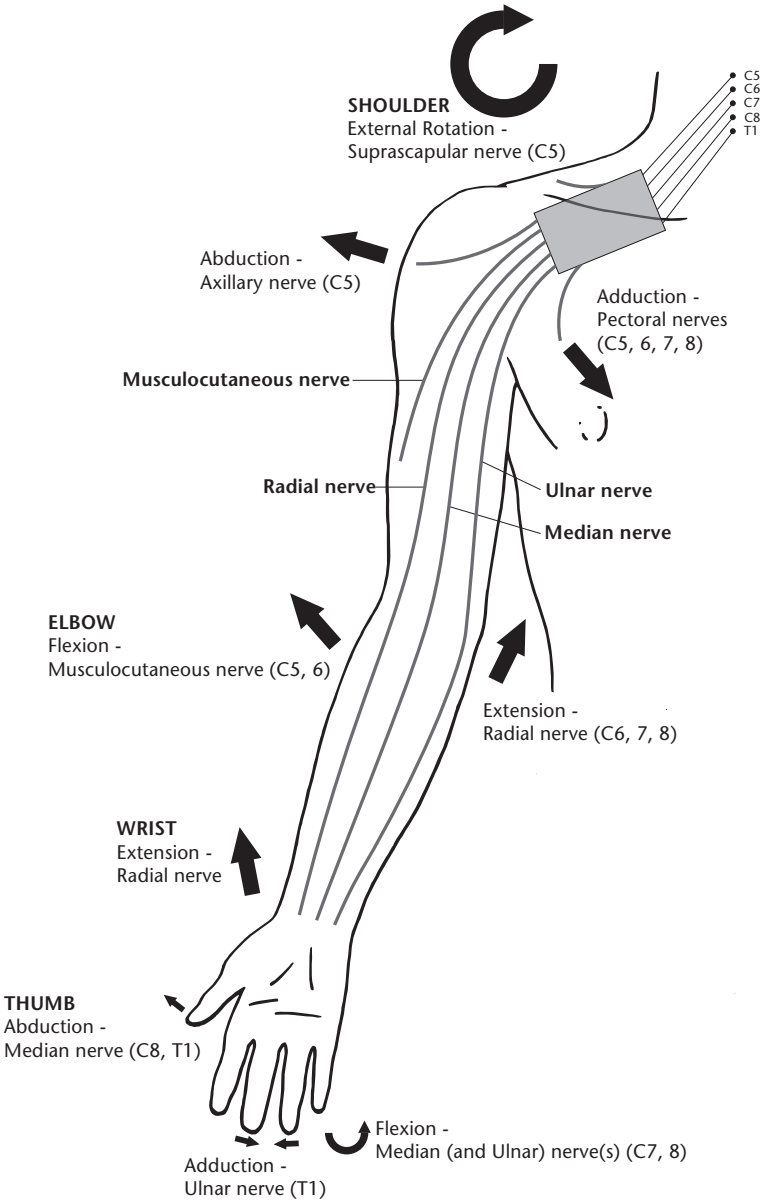
Physiotherapy input is important and it needs to be tailored to suit the individual patient. Reassurance is one of the key issues and it is important to fulfil this role. It may be that the patient only needs to have treatment once every 4 to 6 weeks if they are managing their exercises and have good range of movement.

It may be necessary to provide some form of splinting to aid function or to maintain hand position. If you feel that this would be beneficial and are unable to provide this type of splinting please contact the BPI service.

When planning return visits you should take into consideration the stage of recovery and estimated time for signs of recovery starting. Sometimes early signs of recovery are difficult to detect and this highlights the importance of accurate record keeping. Once a flicker of muscle contraction can be detected the patient should then be started on exercises to maximise this improvement e.g. muscle stimulation (see Appendix 1 A and B for motor point chart), gravity-assisted exercises.

Even the smallest sign of recovery gives the patient tremendous encouragement.

Simplified diagram of the brachial plexus



Extract from 'Guidelines on management and transfer of Brachial Plexus Injury', Scottish Brachial Plexus Injury Service.

Brachial plexus peripheral nerve distribution

Suprascapular nerve C5,6

Shoulder Girdle:

Supraspinatus

Infraspinatus

Long thoracic nerve C5,6,7

Shoulder Girdle:

Serratus anterior

Axillary nerve C5,6

Shoulder Girdle:

Teres minor

Deltoid

Musculocutaneous nerve C5,6

Arm:

Biceps

Coracobrachialis

Brachialis

Median nerve C6-T1

Forearm and Hand:

Pronator teres; Pronator quadratus; APB; Opponens; FCR; Palmaris longus; FDS; FDP to index and middle fingers; FPB (lateral head); Lumbricals

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Radial nerve C6-T1

Arm:

Triceps - long, lateral and medial head

Brachioradialis

Forearm and Hand:

ECRL

ECRB

Supinator; EDC; EDM; ECU; APL; EPB; EI

Ulnar nerve (C7) C8-T1

Forearm and hand:

FCU

FDP (ring and little fingers)

FDMB; ADM; ODM; Interossei; Lumbricals; Adductor pollicis; FPB (medial head)

Brachial plexus peripheral nerve distribution and functional limitations

Nerves	Muscles	Functional limitations
Suprascapular nerve C5, 6 *(Shoulder girdle)*	Supraspinatus Infraspinatus	Weakened lateral rotation of humerus.
Long thoracic nerve C5 - 7 *(Shoulder girdle)*	Serratus interior	'Winged scapula'. Difficulty flexing outstreched arm above level of shoulder. Difficulty protracting shoulder.
Axillary nerve C5, 6	Teres minor Deltoid	Loss of arm abduction. Weakened lateral rotation of humerus.
Musculocutaneous nerve C5 - 7 *(Arm)*	Biceps Coracobrachialis Brachialis	Loss of forearm flexion and supination.
Median nerve C5 - T1	Pronator terres Pronator quadratus APB; Opponens; FCR, Palmar longus; FDS; FDP (to index and middle); FPB (lateral head) Lumbricals	'Monkey hand' deformity. Weakened grip. Thenar atrophy. Unopposed thumb, loss of pinch grip.
Radial nerve C5 - T1 *(Arm)*	Triceps (long, lateral and medial head) Brachioradialis	Absent / weak supination. 'Wrist drop' Extensor paralysis of fingers and thumb.
Radial nerve C5 - T1 *(Forearm and hand)*	ECRL; ECRB Supinator EDC; EDM; ECU; APL; EPB; EI	Loss of wrist, thumb and finger extension.
Ulnar nerve C8 - T1 *(Forearm and hand)*	FCU FDP (ring and little) FDMB; ADM; ODM Interossei Lumbricals AP; FPB (medial head)	'Clawhand deformity'. Interosseus atrophy. Loss of thumb abduction.

Modified from Pedretti, L in Pendleton & Krohn (2006)

Further reading

Birch, R., Bonney, G.W.L., & Parry, W.C.B. (1998)

Surgical Disorders of the Peripheral Nerves

Churchill Livingstone

Lundborg, G. (2004)

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Pendleton, H. M. & Krohn, W. S. (2006)

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Salter. M, & Cheshire, L. (2000)

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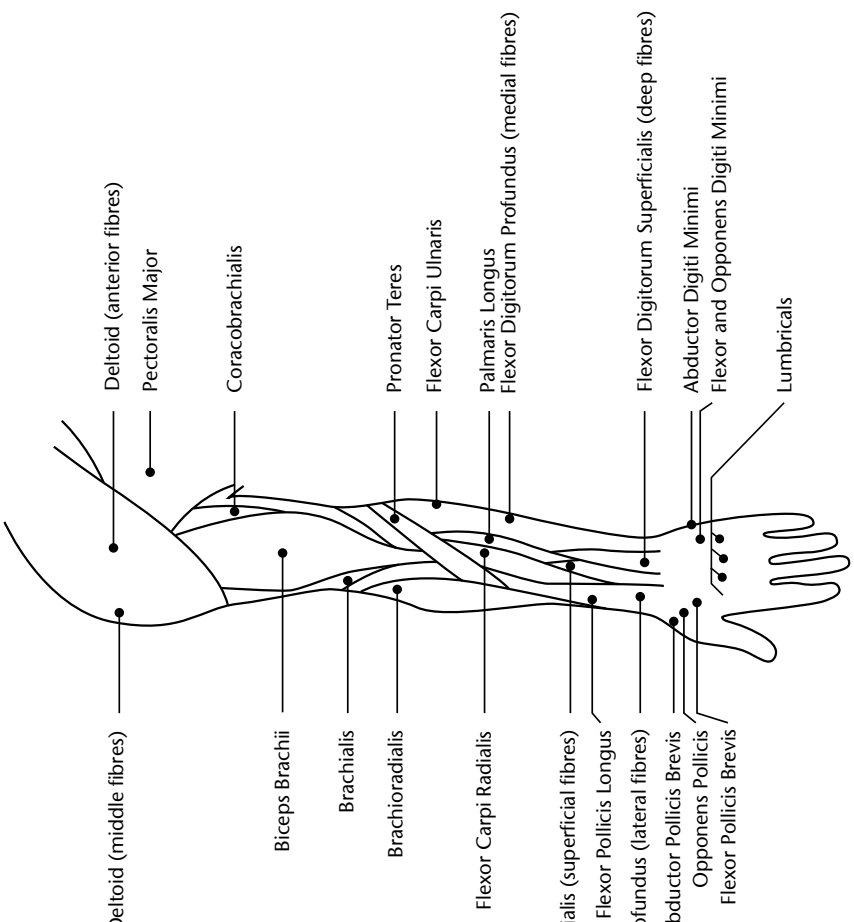
Butterworth Heinmann

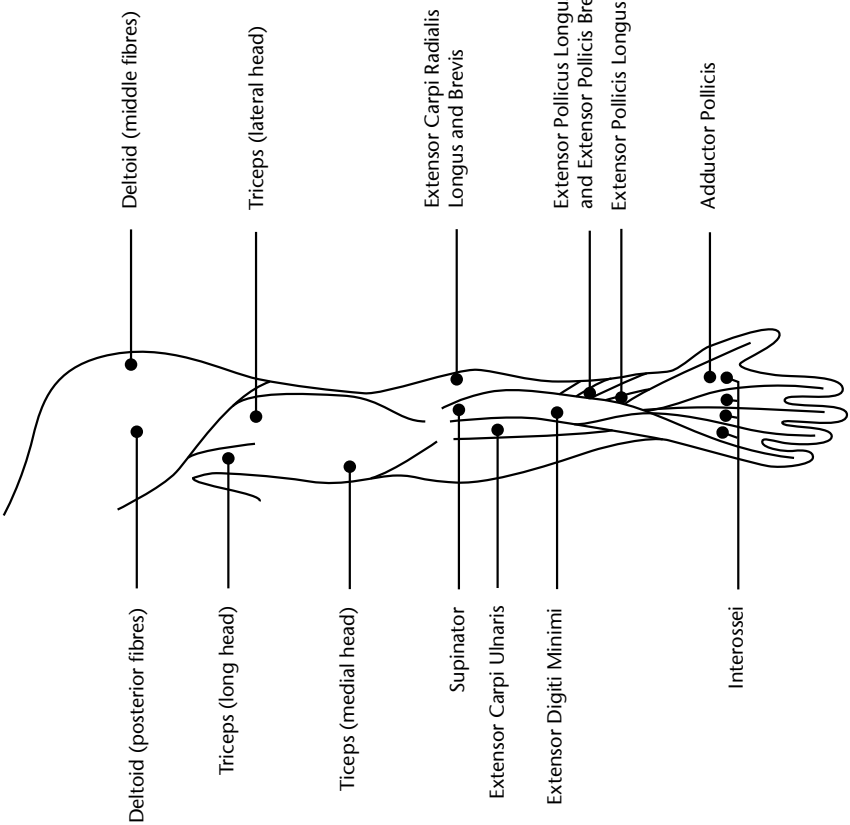
Brown, H., Johnson, K., Beale, S., Miller, C. (2022). **Rehabilitation of Nerve Injuries. In: Phillips, J.B., Hercher, D., Hausner, T. (eds) Peripheral Nerve Tissue Engineering and Regeneration.** Reference Series in Biomedical Engineering(). Springer, Cham. https://doi.org/10.1007/978-3-030-21052-6_17

NOI Group (2024) **Graded Motor Imagery.** https://www.noigroup.com/graded-motor-imagery/(Last accessed 22/07/24)

Appendix 1A - Motor points (anterior aspect of right arm)



Appendix 1B - Motor points (posterior aspect of right arm)



Appendix 2 - Exercise Programme

The text and illustrations below are an extract from the patient information booklet for brachial plexus injury patients 'Scottish National Brachial Plexus Injury Service - Information for Patients'. Further patient information is available from the service website

Physiotherapy Exercise Programme

The following programme of exercises is designed to help you be as independent as possible while doing the exercises.

You will be told when you are ready to start these exercises. A physiotherapist will show you exactly what you have to do.

The shoulder and elbow exercises are usually started at 4 to 6 weeks, once the Polysling has been removed. The wrist and hand exercises can be done while the Polysling is on. You should repeat each exercise 10 times, twice or three times each day.

Shoulder exercises

1. Lying on your back, clasp your affected arm by the wrist or hand and lift your arm above your head. This should gradully improve until you are able to take your arm all the way above your head as shown.

1. Shoulder

2. You will need help with this exercise. The person helping you puts one hand across the top of your shoulder to stop it moving. With their other hand they grasp around your elbow and then fix your forearm between their body and side. Your arm is then moved out to the side as far as possible

2. Shoulder

3. You will need help with this exercise. The helper holds around your elbow to keep your arm close to your side. Their other hand holds around the wrist and in this position turns your arm out towards them.

3. Shoulder

4. Once your movement improves enough for you to reach above your head, you can stop exercises 2 and 3 and use this combined exercise instead.

   Lift your affected arm up as far as you can and put your hands behind your head. In this position, stretch your elbow back towards the pillow.

4. Shoulder

Elbow exercises

5. While standing, hold your affected arm around the wrist and help bend your elbow up as far as you can.

5. Elbow

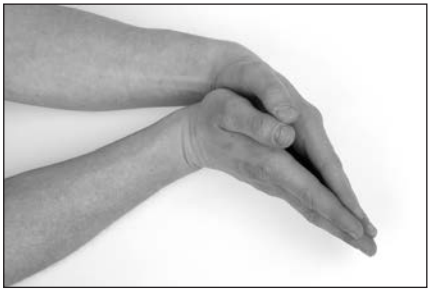
6. Straighten your elbow out as far as you can. To help you get more straightening, place your other hand behind the point of elbow.

   If you find this difficult, try adding a light weight as shown below.

6. Elbow. Try adding a light weight to help straighten your elbow.

Wrist exercises

7. While seated, help your affected hand by putting palm to palm and push the wrist back.

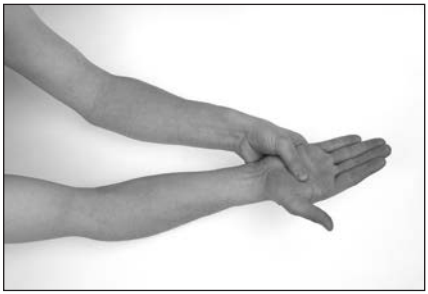


7. Wrist

8. While seated, place your unaffected hand over the back of your affected hand and bend the wrist forward.

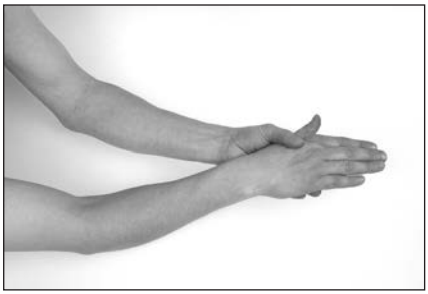
8. Wrist

9. Hold your affected hand in the mid part of the palm and turn your hand up.



9. Wrist

10. Hold your affected hand in the mid part of the palm and turn your palm down.



10. Wrist

Hand exercises

11. Use your unaffected hand to help bend your fingers into your palm. Make sure you bend your fingers from the knuckles so you are curling your fingers as much as possible.

11. Hand

12. Spread your fingers by placing the fingers of your unaffected hand in between the fingers of your affected hand and strech them apart.

12. Hand

Thumb exercises

13. Stretch your thumbs across your palm as far as you can.

13. Thumb

14. While seated, fix your hand between your knees and stretch your thumb away from the fingers.

14. Thumb