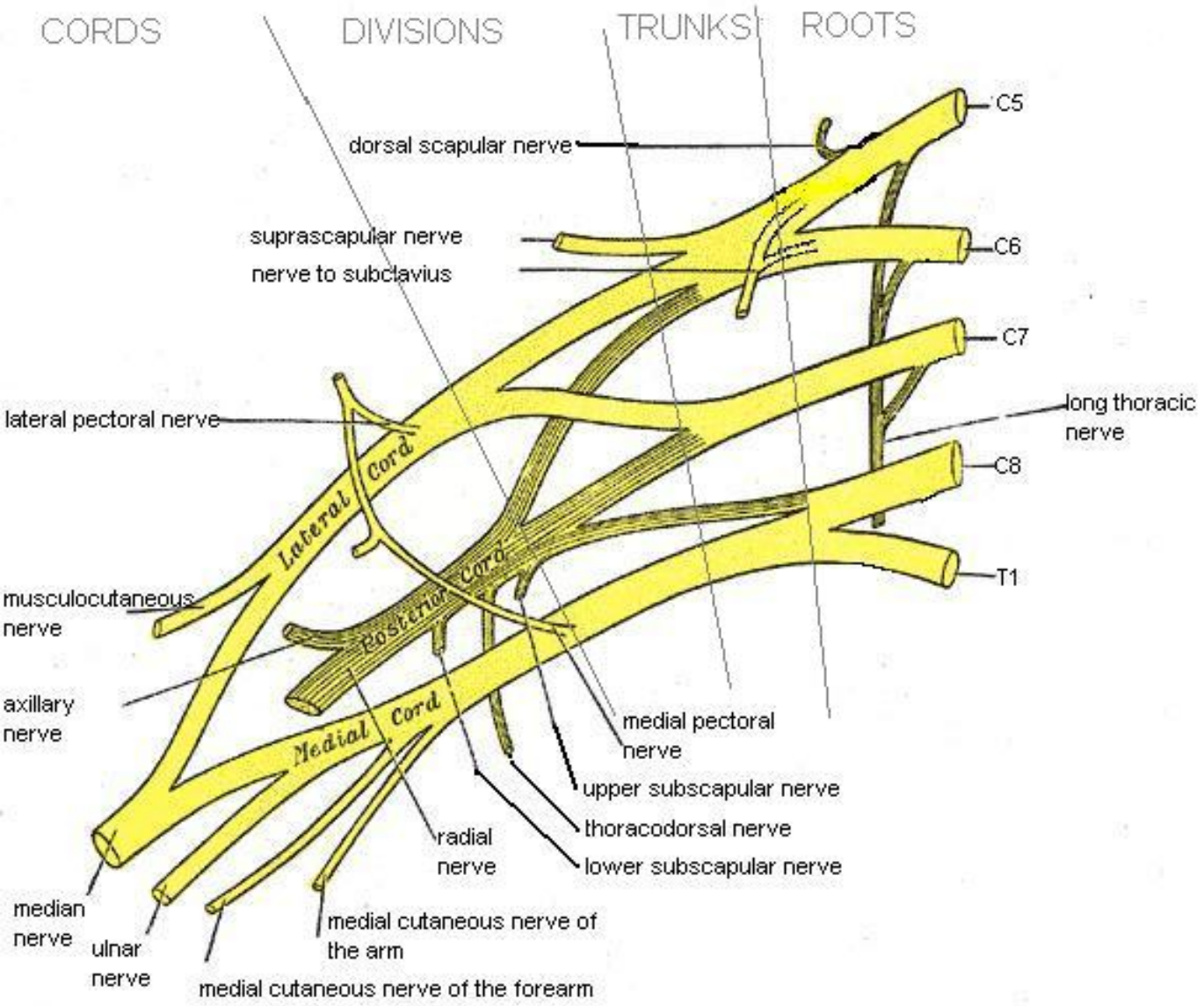
BRACHIAL PLEXUS ANATOMY, INJURIES AND MANAGEMENT

- Brachial plexus is network of nerves that supply sensation and motor function to upper extremity
- Formed by ventral primary rami of lowest four cervical and upper most thoracic nerve (c5-T1)

Anatomy

- Roots - c5 – t1
- Trunks – Upper ,middle and lower
- Division- Anterior and posterior
- Cords – Medial, posterior and lateral
- Branches



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Branches

- Roots -

  phrenic nerve – C3,4,5 – diaphragm

  Long thoracic n - c5,6,7 – serratus anterior

  dorsal scapular n – c5 - rhomboidus ,

  levator scapulae

- Trunk -

  suprascapular n – c5- supraspinatus

  infraspinatus

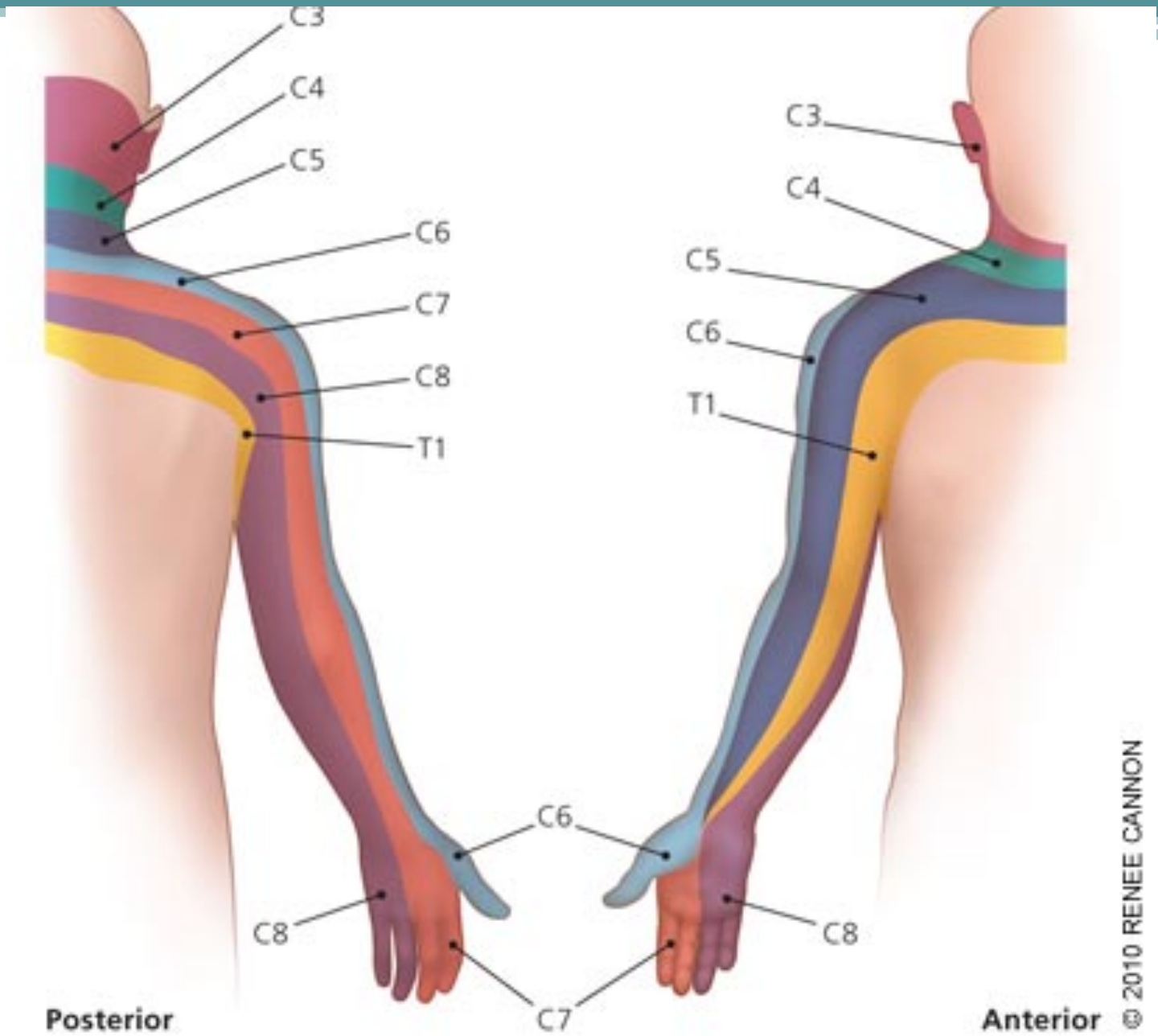
Branches of cord

- Lateral cord
  - lateral pectoral nerve

- Medial cord
  - medial cutaneous nerve of arm
  - medial cutaneous nerve of forearm
  - medial pectoral nerve
- posterior cord
  - upper and lower subscapular nerve
  - thoraco-dorsal nerve (c6-8)

- Lateral cord –
  musculocutaneous nerve (c5,6,7) and
  contribute to medial nerve
- Posterior cord – axillary(c5-6) and radial nerve (c5-t1)
- Medial cord – median nerve contribution and ulnar nerve (c8-T1)

Roots	Sensory	Motor Deficits	Reflex
C5	Lateral border upper arm to elbow	Deltoid Supraspinatus Infraspinatus Rhomboids	Biceps
C6	Lateral forearm Thumb, index	Biceps Brachioradialis Brachialis	supinator
C7	Middle finger, Front & back of hand	Triceps Wrist flexors & Extensors Lat.dorsi,Pec major	triceps
C8	Little finger Heel of hand to above wrist	Finger flexor & extensor Flexor Carpi ulnaris	finger
T1	In the axilla	All small hand muscles	none


C3
C4
C5
C6
C7
C8
T1
C6
C8
C7
Posterior
C3
C4
C5
C6
T1
C6
C8
Anterior
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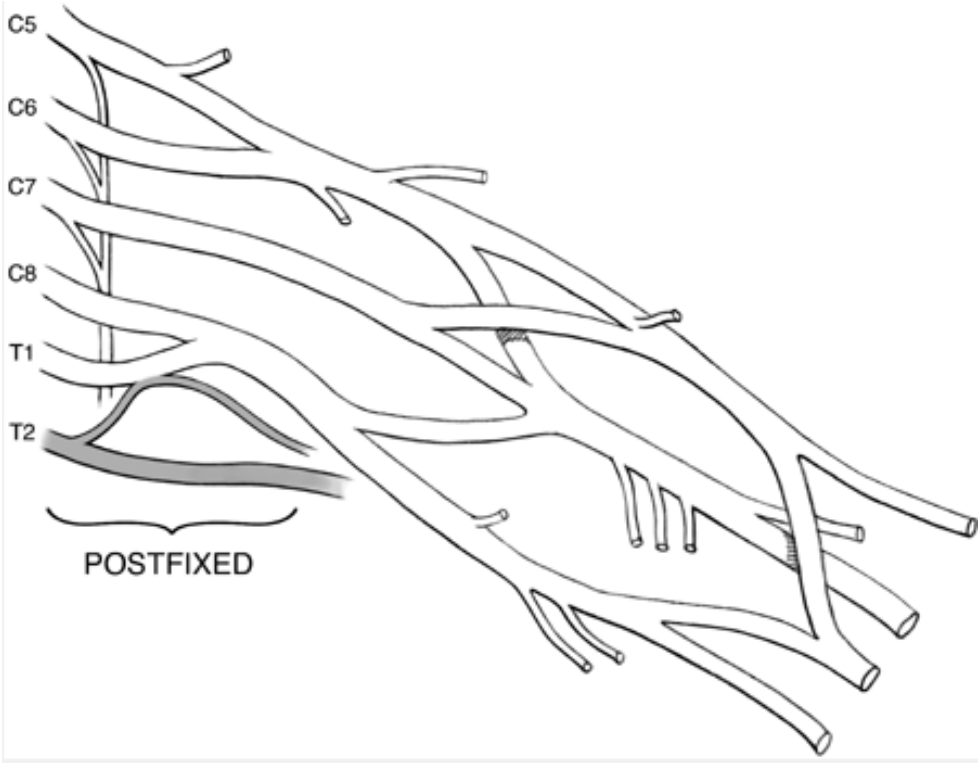
Variations

- Pre-fixed (28-62%)

post-fixed (16-73%)



http://www.msdlatinamerica.com/ebooks/HandSurgery/sid744608.html

Injuries of brachial plexus

- Most common cause of injury – RTA (70%)

- Obstetrics
- Iatrogenic – positioning , surgical trauma .
- Miscellaneous - radiation , tumors ,neuritis .

Patho-anatomy

- Lack of connective tissue or meningeal envelope over rootlets and roots
- The spinal nerve is able to move freely in the foramina due to non attachment to it.
- Fibrous attachment of spinal nerves to the transverse process seen in the 4^{th} through 7^{th} cervical roots - high incidence of root avulsions in C8-T1 roots

Pathogenesis

- Bimodal distribution:
  Obstetrical: male = female. R> L
  Ages 15 -30, males (MVA, violence)
- 70% RTA
- Usually closed
- Supraclavicular more common

Traction Injury

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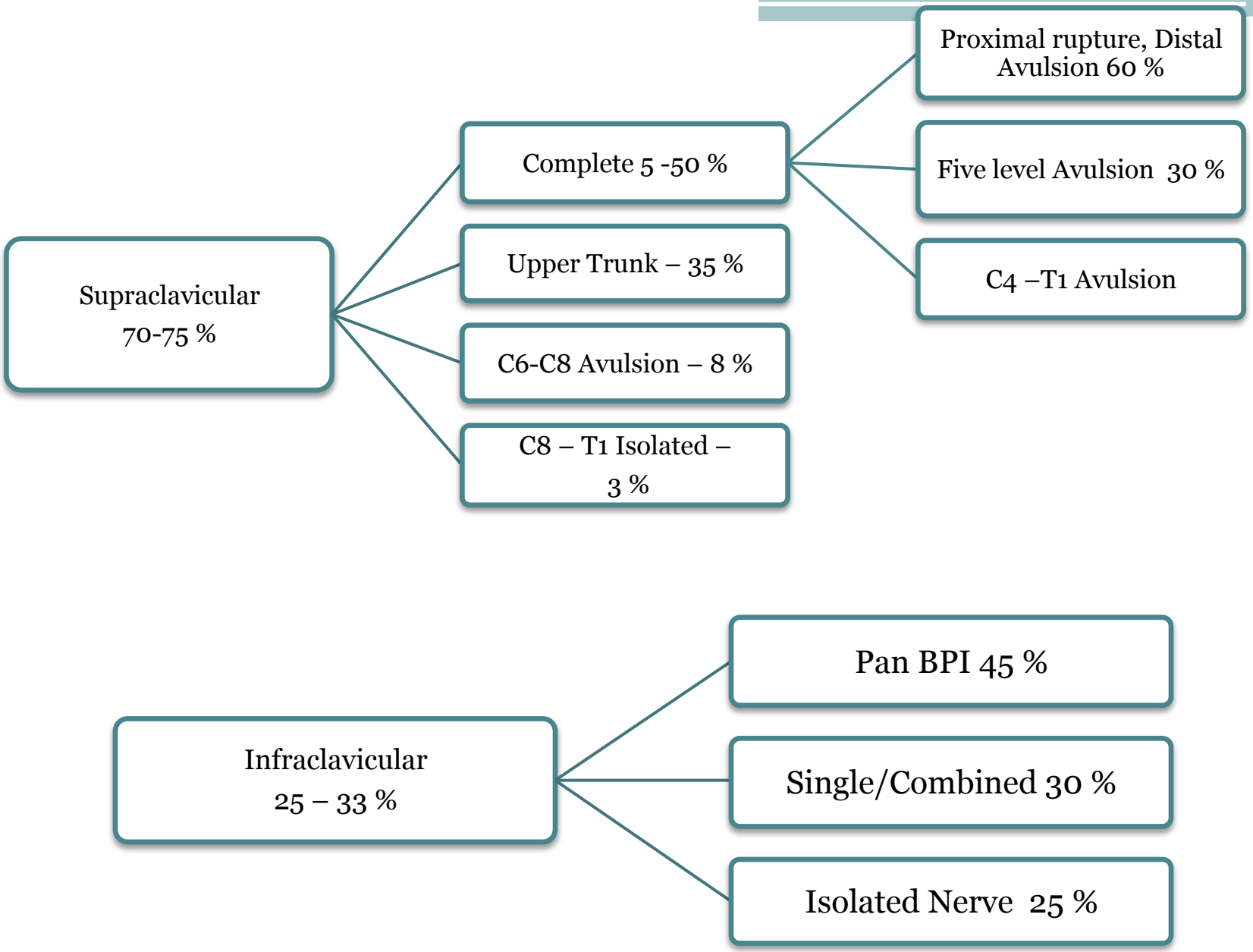
Classification of injuries

- Open v/s closed
- Supra v/s infraclavicular
- Pre v/s post ganglionic
- Complete v/s incomplete


Supraclavicular
70-75 %
Complete 5 -50 %
Upper Trunk – 35 %
C6-C8 Avulsion – 8 %
C8 – T1 Isolated –
3 %
Proximal rupture, Distal
Avulsion 60 %
Five level Avulsion 30 %
C4 –T1 Avulsion
Infraclavicular
25 – 33 %
Pan BPI 45 %
Single/Combined 30 %
Isolated Nerve 25 %

Clinical features

- Brachial plexus injury is often seen in conjunction with significant trauma .

- High suspicion for brachial plexus injury should maintained when pt had shoulder girdle injury , first rib #, axillary artery injury .

Clinical features

- Roots level (pre-ganglionic) –
  - winging of scapula
  - phrenic nerve involvement
  - atrophy of rhomboidus and parascapular muscle
  - horner's syndrome (T1)

- Trunk level –

  Upper trunk - shoulder elevation and external rotation

  atrophy of posterior aspect of shoulder (infraspinatus)

- Posterior cord –
  wrist extension, elbow extension and shoulder abduction.
  Latissimus dorsi , teres major

- Wrist and finger movement – radial , ulnar and median nerve .
- Arm & elbow flexion and extension – musculocutaneous and high radial function

- Assess spinal accessory nerve
- Rule out cord injury (myelopathy)
- Tinel's sign
- Vascular examination
- Look for Fractures
- Look for associated injuries.

Investigation

- Imaging
  - Plain radiograph
  - Myelography
  - CT myelography
  - MRI – conventional myelography

- Electro-diagnostic study

- Plain radiograph – Cervical spine , CXR , Shoulder AP & axillary.

MRI

- Pseudomeningocele
- Cord signal changes
- Enhancement of intra dural nerve roots
- Abnormal enhancement of paraspinal muscles
- Visualization of post ganglionic plexus (neuroma)
- MR myelography –diagnostic accuracy equivalent to CT myelography .

- When MRI is contraindicated then

  Myelography
  CT Myelography- gold standard for root injury, done at 3 to 4 weeks to see for pseudo meningocoele formation

Current advances

- Neurography
- Coronal oblique volumetric MRI
- CISS
- Fast imaging employing steady-state acquisition (FIESTA)

Electro- diagnostic study

- Can help confirm a diagnosis
- Localize lesions
- Define severity of axon loss and completeness of lesion
- Serve as an important adjunct to thorough history , physical exam and imaging study

- For closed injuries EMG and NCV can best be performed 3 to 4 weeks after the injury because wallerian degeneration will occur by this time

SNAP

- Pre-ganglionic injury – normal SNAP with sensory loss
- Post-ganglionic – decrease amplitude

EMG

- Denervation changes (fibrillation potentials) can be seen in proximal muscles 10 to 14 days and 3 to 6 weeks post injury in most distal muscles
- Reduced MUP (motor unit potential) recruitment can be shown immediately after weakness from LMN injury
- Presence of active motor units with voluntary effort and few fibrillations at rest has good prognosis
- Can help in distinguishing preganglionic from postganglionic lesions

	Pre ganglionic	Post ganglionic
Neuropathic pain	present	Absent
Horners	present	Absent
Proximal girdle muscle weakness	present	Absent
CMAP	Normal	Reduced amplitude
SNAP	Normal	Reduced amplitude
EMG	Paraspinal Muscle Fibrillation potential	Decreased MUP recruitment
Myelography	Pseudomeningocele , root avulsion	

Management

- Conservative v/s operative

- Timing of surgery

- Isolated injury limited to C 8,T 1 /lower trunk/ medial cord should be treated non operatively as less likelihood of recovery .

Timing of surgery

- Acute exploration
  - open injury with sharp laceration
  - concomitant vascular injury
  - crush and contaminated wound
- Early exploration (1 – 2 weeks)
  - unequivocal complete C5- T1 avulsion injury
- Delayed exploration (> 3 months)
  - recommended for complete injuries with no recovery by clinical examination or EMG at 12 weeks post injury
  - candidates showing distal recovery without regaining clinical or electrical evidence of proximal muscle function

Priority

- Elbow flexion
- Shoulder abduction , external rotation and scapular stabilization
- Function of long thoracic nerve restored whenever possible
- Radial nerve motor function can often be restored with triceps function more likely to return
- Sensation in median nerve distribution restored if possible (pain)

Treatment options

- Neurolysis
- Nerve repair
- Nerve graft
- Nerve transfer (neurotization)
- Nerve root replantation
- Free muscle and tendon transfer

Neurolysis

- Effective only if scar tissue seen around nerve or inside epineurium, preventing recovery or causing pain
- Pre and post neurolysis direct nerve stimulation is mandatory to evaluate improvement in nerve conduction

Nerve repair

- Used in sharp transection with excellent fascicular pattern and minimal scar
- Tension Should be Avoided

Nerve graft

- Indicated for well defined nerve ends without segmental injuries
- Intraoperatively a good fascicular pattern should be seen after the neuroma is excised
- Possible sources: sural, brachial cutaneous nerve, radial sensory and possibly ulnar nerve
- graft orientation should be reversed to minimize axonal branch loss
- Surgical technique, length .

Neurotization

- Intentional transfer of functional but less important nerve to damaged but more important nerve .

Neurotization

Intraplexal	Extraplexal
Undamaged roots	Spinal accessory
Medial pectoral	Intercostal
Medial cord	Phrenic
Ulnar nerve	Motor branch of cervical plexus
MCNA	
MCNFA	

Options for Neurotization

- Supra scapular - spinal accessory
  phrenic nerve
  C7 fascicle
- Musculocutaneous - ulnar
  intercostal
  medial pectoral
- Axillary - phrenic
  spinal accessory
  medial pectoral or intercostal

- Spinal accessory nerve – only distal branch should be used to avoid denervation of trapezius

- Intercostal nerve –small length .
- Phrenic nerve – respiratory complications contraindicated in abnormal hemidiaphragmatic motions.

Oberlin Technique

- Biceps reinnervation using one or two ulnar nerve fascicle , mostly flexor carpi ulnaris.
- Neurotization close to end organ .

Plexo-plexal transfer

- Contra lateral C7 transfer – complete plexopathy with multiple avulsion with limited donor possibilities.

Salvage procedure

FREE MUSCLE AND TENDON TRANSFER

- Restoration of elbow function in late presenting patient
- Gracilis is used .

- Chest X ray
- 3-6 weeks immobilization
- Physiotherapy
- Electrical stimulation
- Re- education of muscles
- Follow up Electro diagnostic studies
- Occupational therapy
- Limb reconstruction
- Psychotherapy

Prognosis

- Pattern of injury
- Complete C4 to T1 injuries are considered most severe and virtually irreparable
- Avulsion injuries from C5 toT1 amenable to restoration of shoulder and elbow function only
- Ideal candidate for surgery are patients with proximal rupture or avulsion and sparing of lower trunk

AIIMS study

- Since 1995 to2002 , 505 patients were studied for functional and occupational outcome after surgery for BPI
- In India BPI is most common due to RTA with right side involved in 2/3
- 40% cases have pan BPI
- 85% of cable graft yielded improvement in motor power compared to 68% in neurotized nerve and 66% in patients undergoing neurolysis

- Most effective donor nerve for musculocutaneous neurotization was medial pectoral nerve, 63.6% patient improved
- Accessory nerve was most effective for neurotization of suprascapular nerve (100%)
- Thoracodorsal axillary neurotization gave (66.7% improvement)
- 50% patients either remained unemployed or had to change their jobs.

Recent advances

- Direct ventral intraspinal implantation
- Sutureless repair
- Stem cells
- Synthetic Nerve grafts

Management of obstetrical palsy

- Spontaneous recovery is seen in 65 – 100 % .
- Most important indicator of recovery appears to be biceps function at end of 3 months .
- Surgery recommended for patient with less than antigravity power of biceps ,triceps or deltoid at end of 6 months .

Thank you