Brachial Plexus Injury- Surgical Management

Presenter
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Moderator
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Historical Aspects

- First surgical repair of BPI – Late 1900's

- Results however – disappointing

- Mid-1960's – Narakas and Millesi
- ✓ Microsurgical techniques for nerve grafts coaptation developed

- Improved diagnostic modalities –
- ✓ EMG/NCV
- ✓ CT myelography
- ✓ MRI

Key Elements in BPI Mx

- Non-operative care
- Selection
- Timing
- Priorities
- Methods

Non-operative Care

- Stabilization of life threatening injuries
- Maintaining range of motion of joints, muscles and tendons
- Aggressive physiotherapy
- Splints or casts if required
- Mx of Neuropathic pain – Anticonvulsant + Opiods

Timing of Surgery

Primary Surgery

- Penetrating Injury – Immediate exploration & repair

- Stretch Injury – 3-4 months after injury

✓To allow spontaneous recovery

✓Intra-op EPS to assess recovery

Secondary Surgery

❖ Primary Nerve repair is unlikely to be beneficial

❖ Recovery after NR reaches a plateau still lacking fn.

❖Old Injury > 2yrs

- Birth Related BPI – 2-3 months of age
- Good prognosis in general > 90% patients
- EMG – Not reliable assessment tool in infants

- Indicators of poor prognosis and severe injury –

✓ Biceps paralysis at 3 months
✓ Wrist drop at 3 months
✓ Absence of external shoulder rotation at 3-4 months

Priorities of the Surgical Targets

- Elbow Flexion
- Shoulder stability and active abduction
- Protective sensation of hand and arm
- Wrist Extension
- Finger Flexion
- Finger Extension
- Wrist Flexion
- Intrinsic muscles of hand

Surgical Management

- Primary/Initial (Fascicular/Epineural coaptation)
  - ✓ End to End nerve repair
  - ✓ End to side nerve repair
  - ✓ Nerve Grafting
  - ✓ Nerve transfer
  - ✓ Neurolysis

- Secondary/Delayed
  - ✓ Musculo-tendinous transfers

Severity of Nerve Injury – Sunderland's Classification

- I – Conduction block without Wallerian degeneration
- II – Axonal injury with intact Endoneurium
- III – Endoneurium is additionally injured
- IV – Perineurium surrounding fascicle also disrupted
- V – Complete Nerve rupture including Epineurium

Spontaneous Recovery – Not anticipated in Type IV & V

- Type I & II – Spontaneous recovery
- Type III – Neurolysis/Conservative Mx
- Type IV & V – Neuroma excision + Neurotization

- Intra-op differentiation of type III & type IV injury –

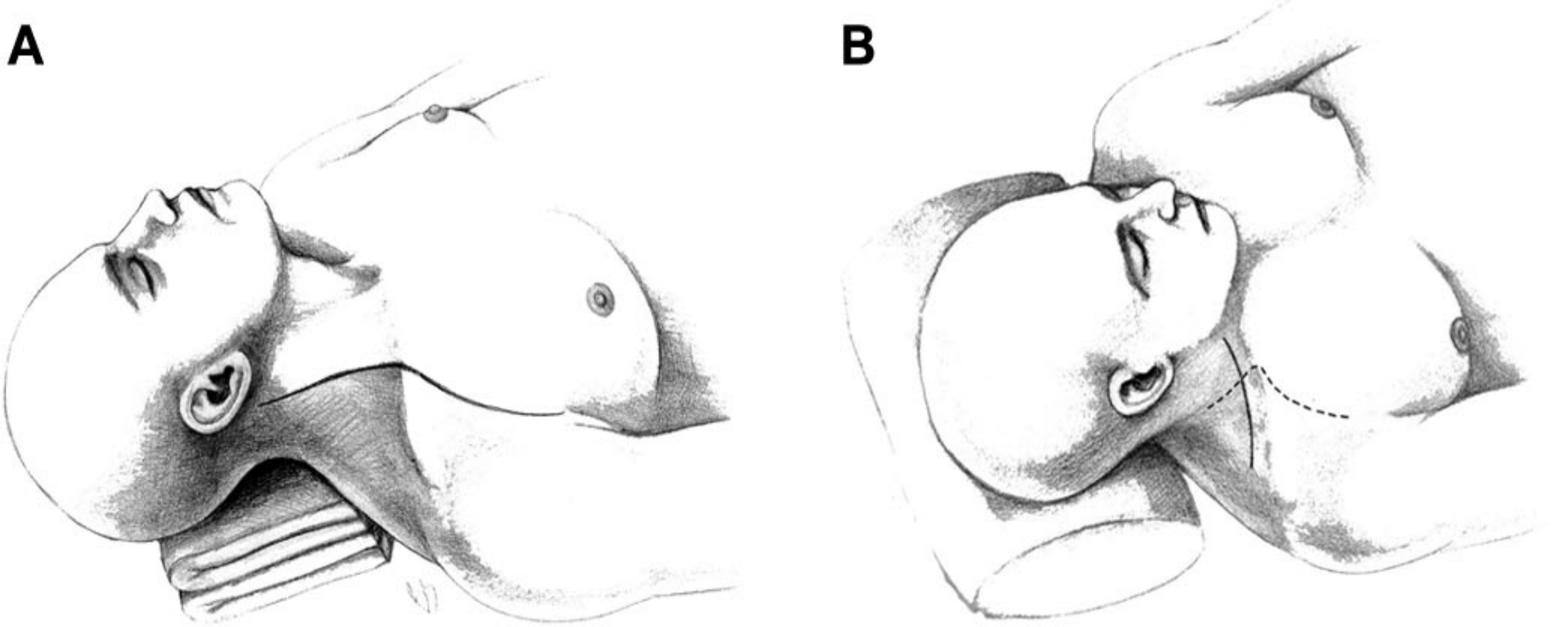
  Nerve action potential (NAP) –

✓ Small amplitude and slow conduction across neuroma s/o 90% chance of recovery with neurolysis alone

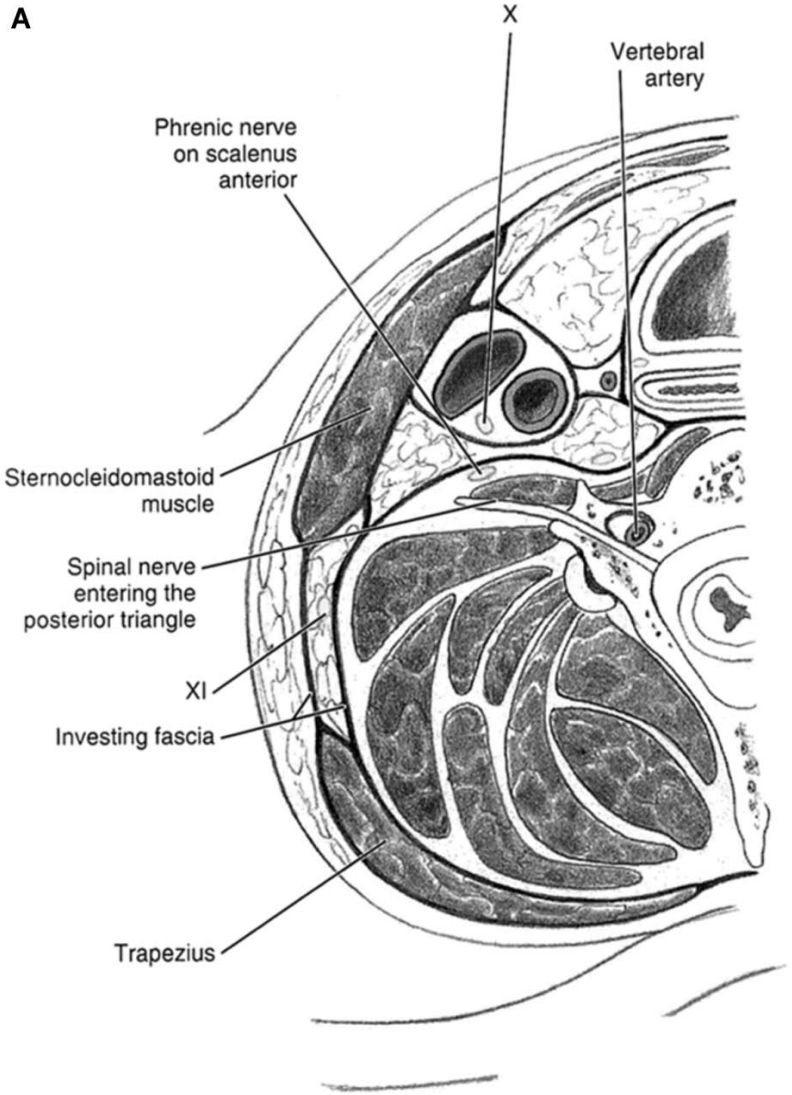
Surgical Exposure

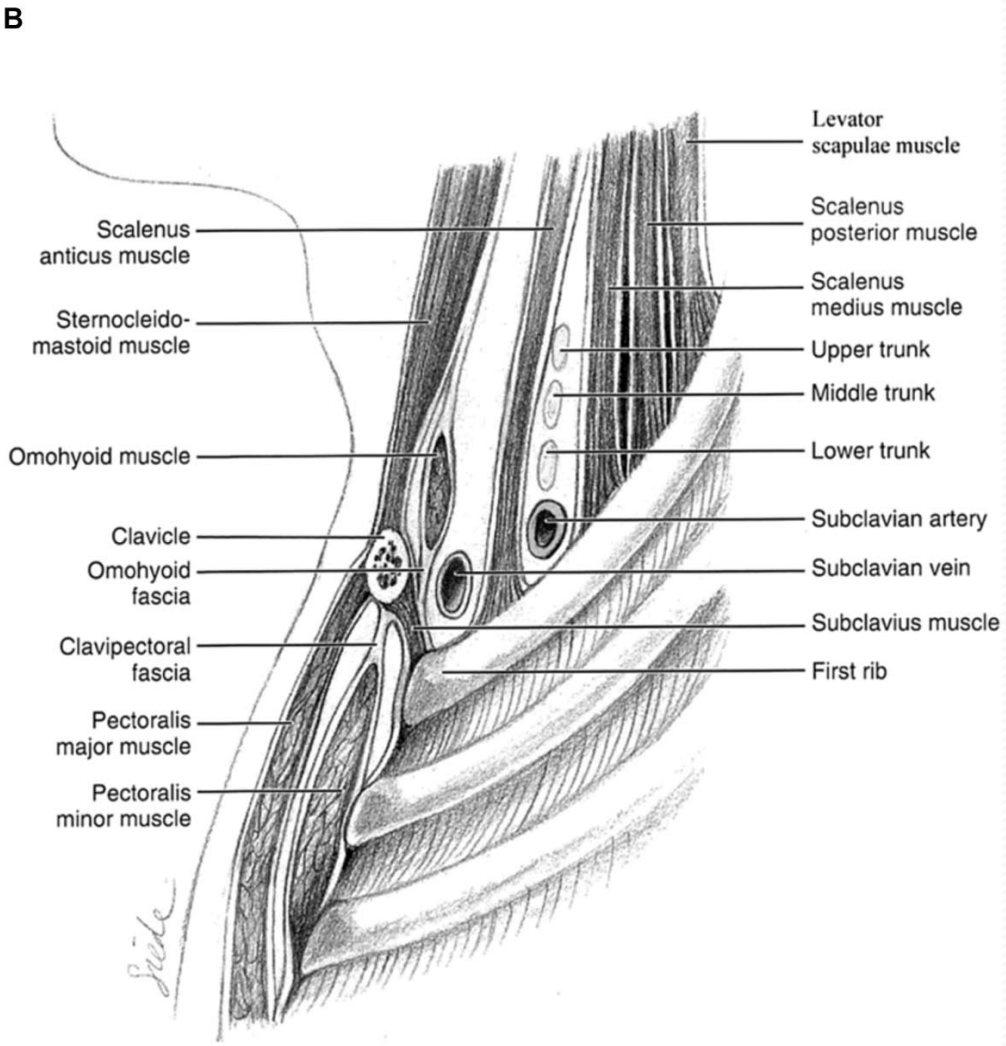
- Supraclavicular Approach
- Infraclavilcular Approach
- Posterior-Subscapular Approach

Supraclavicular Approach – Incision

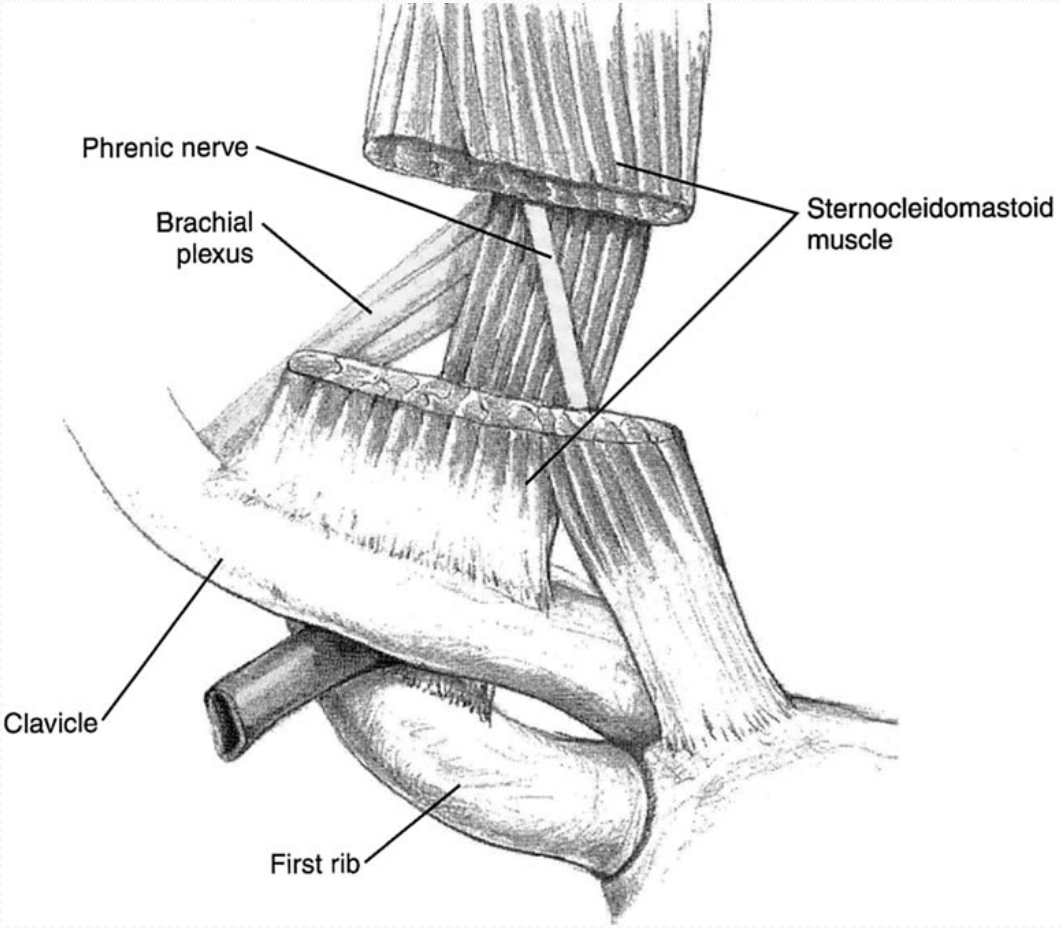


Axial and Saggital Sections

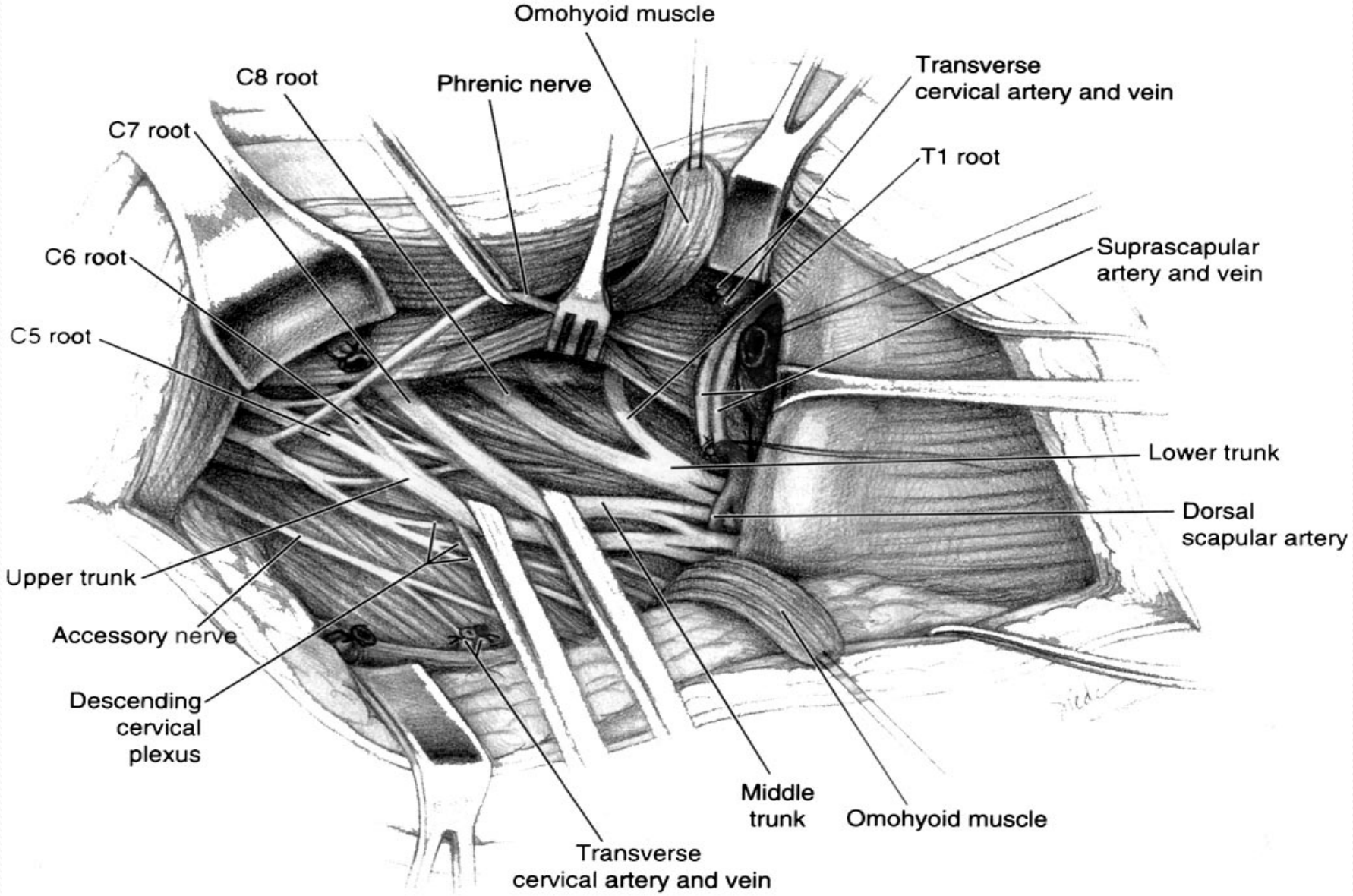




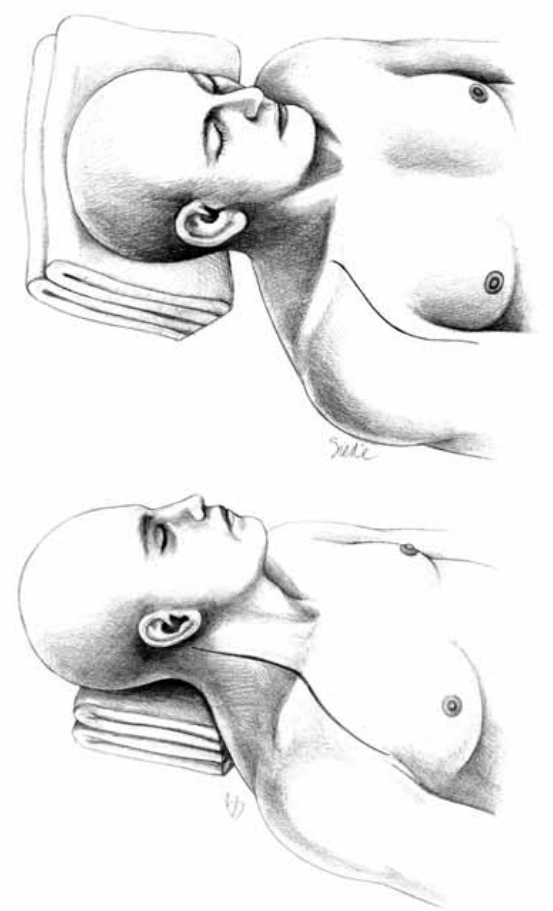
Relation of Brachial plexus

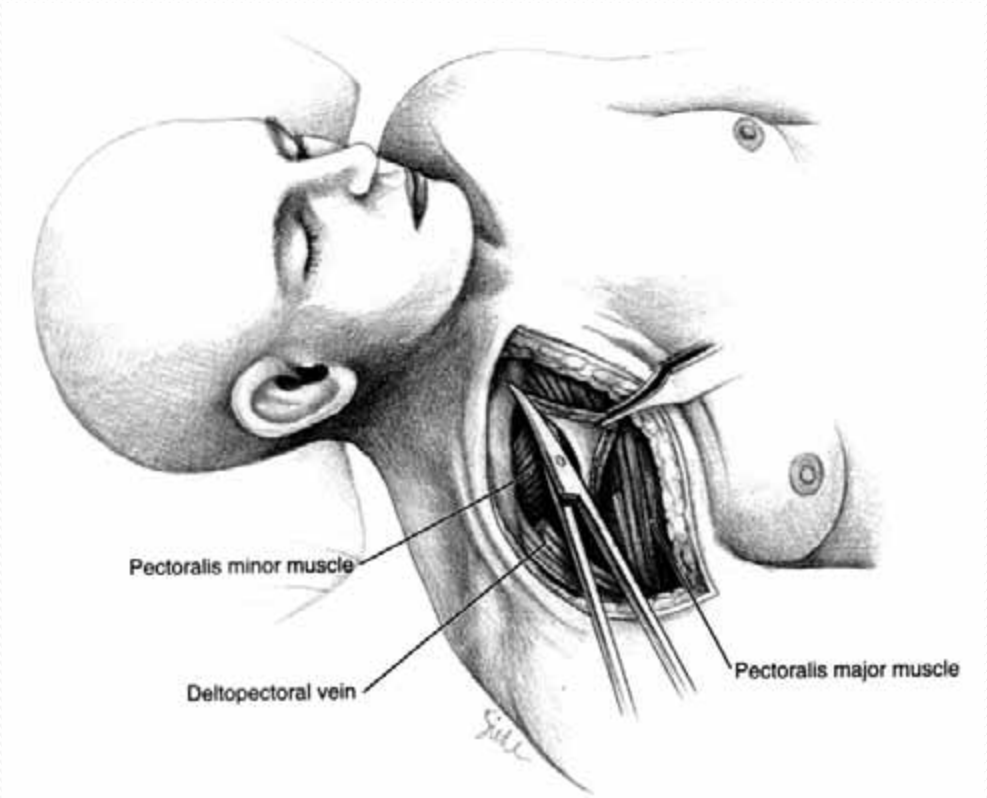


Complete Supraclavicular Exposure

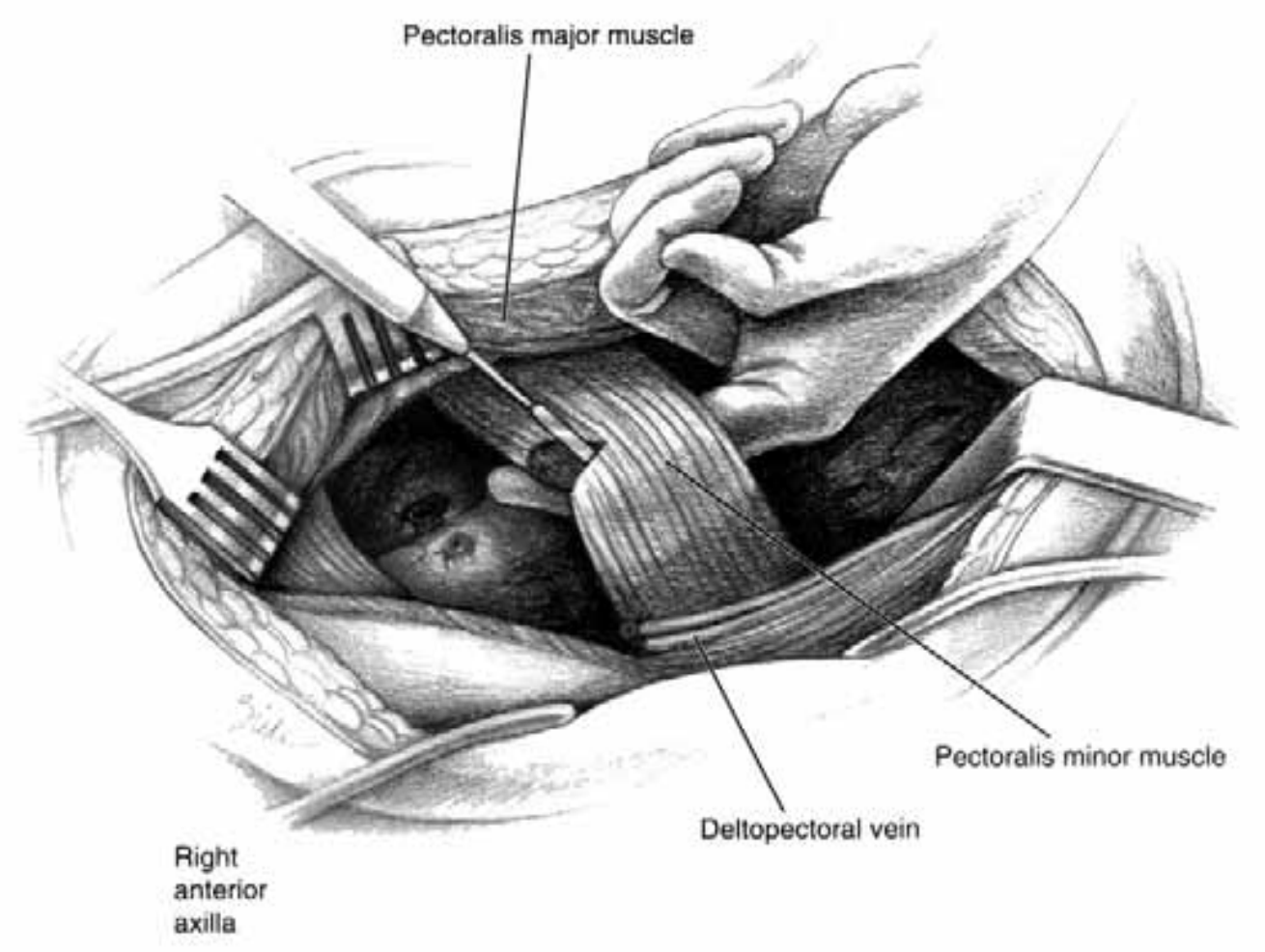


Infraclavilcular Approach -Incision

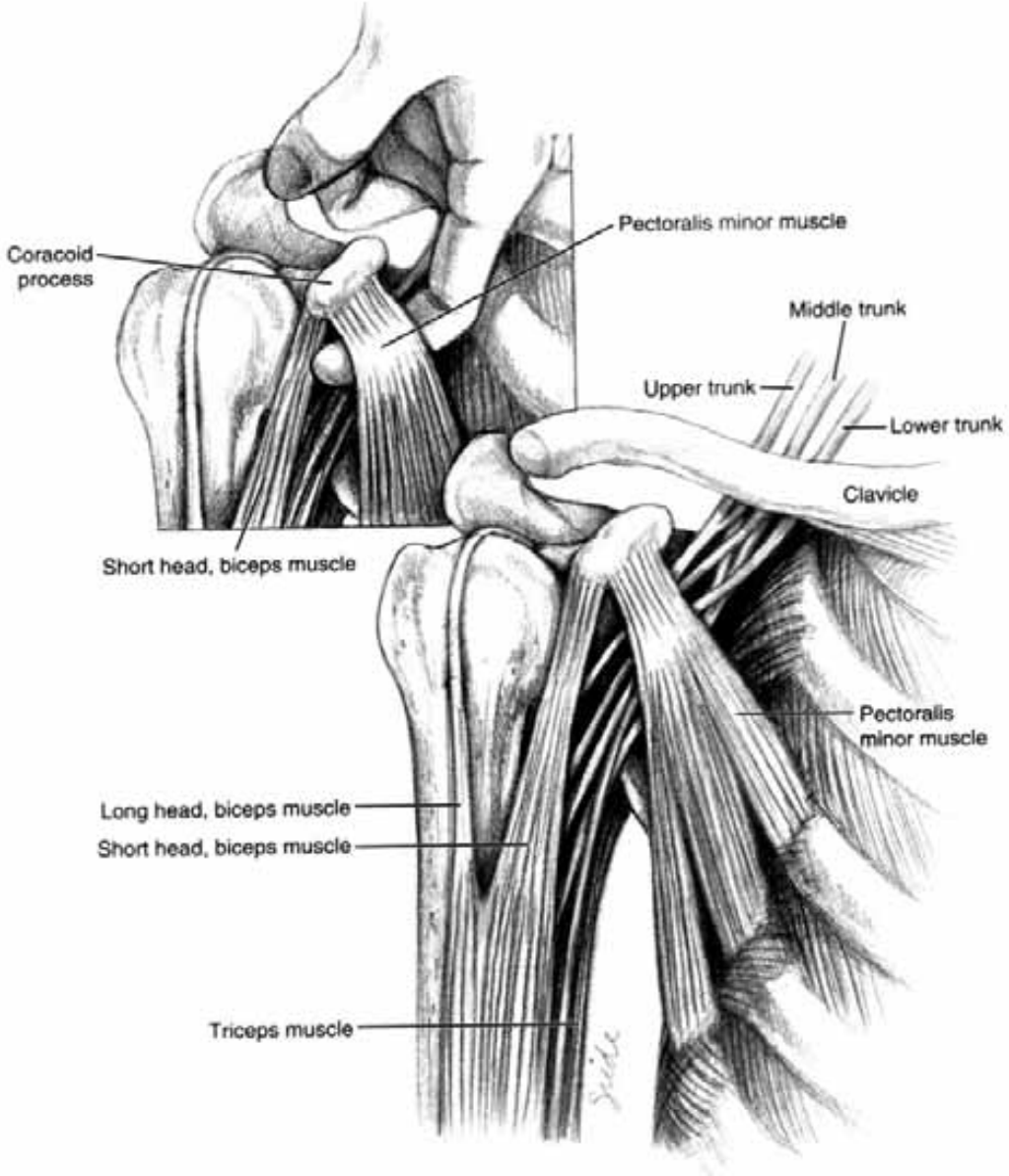


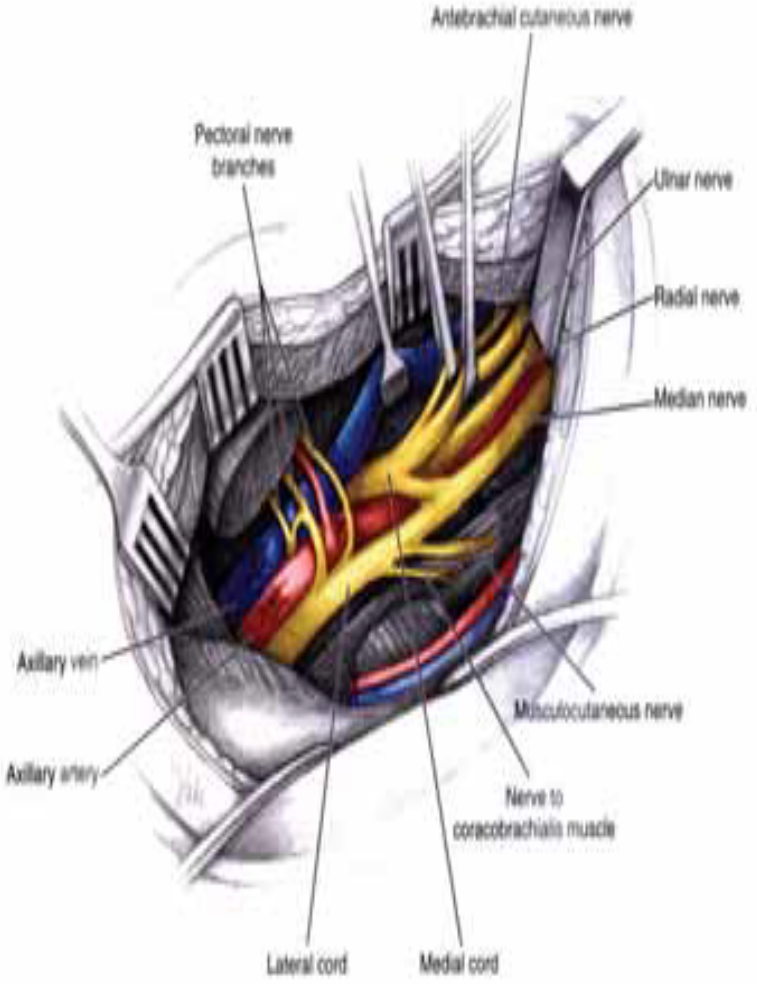


Exposure

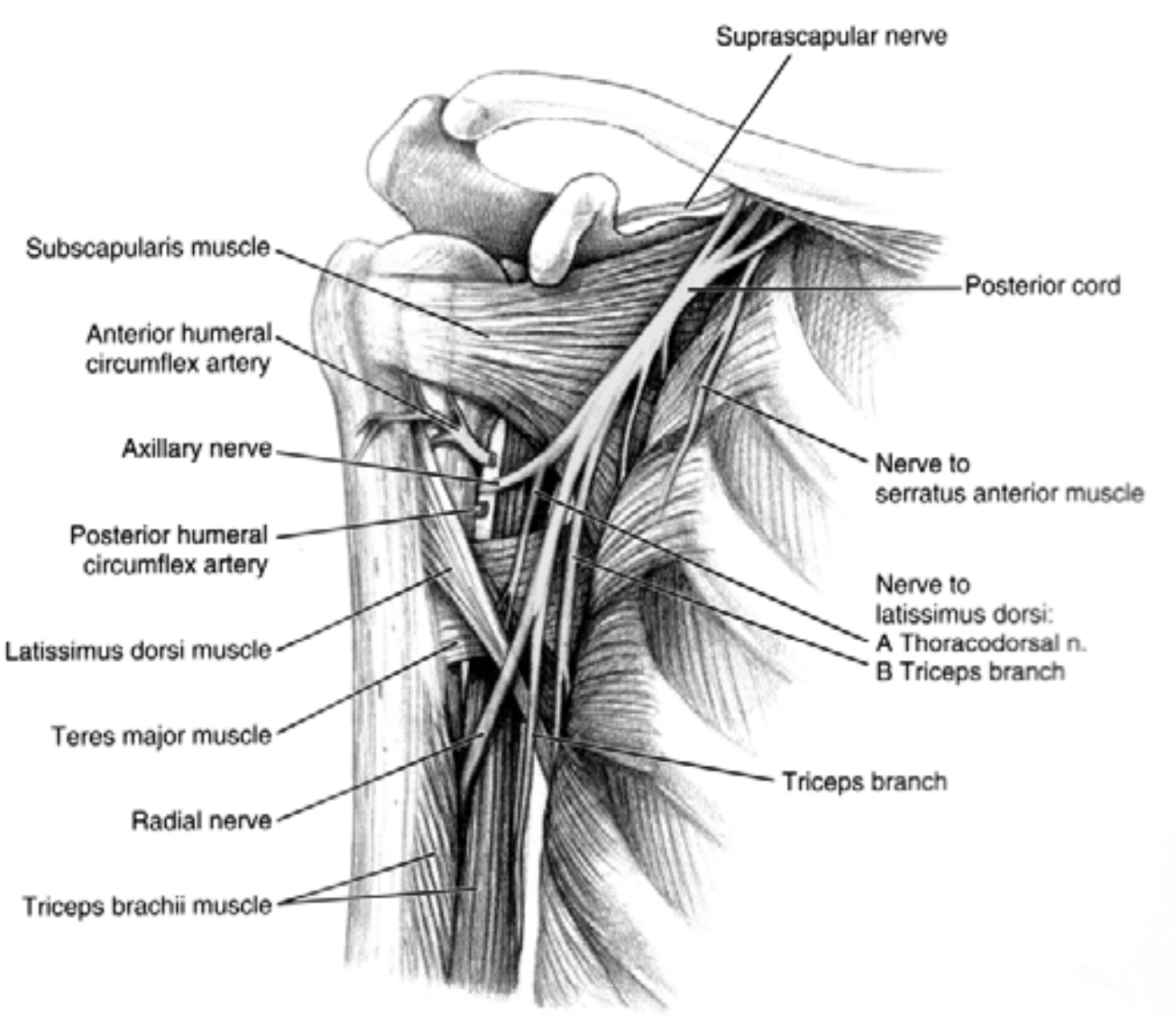

Pectoralis major muscle
Pectoralis minor muscle
Deltopectoral vein
Right
anterior
axilla

Lateral and Medial Cord - Branches

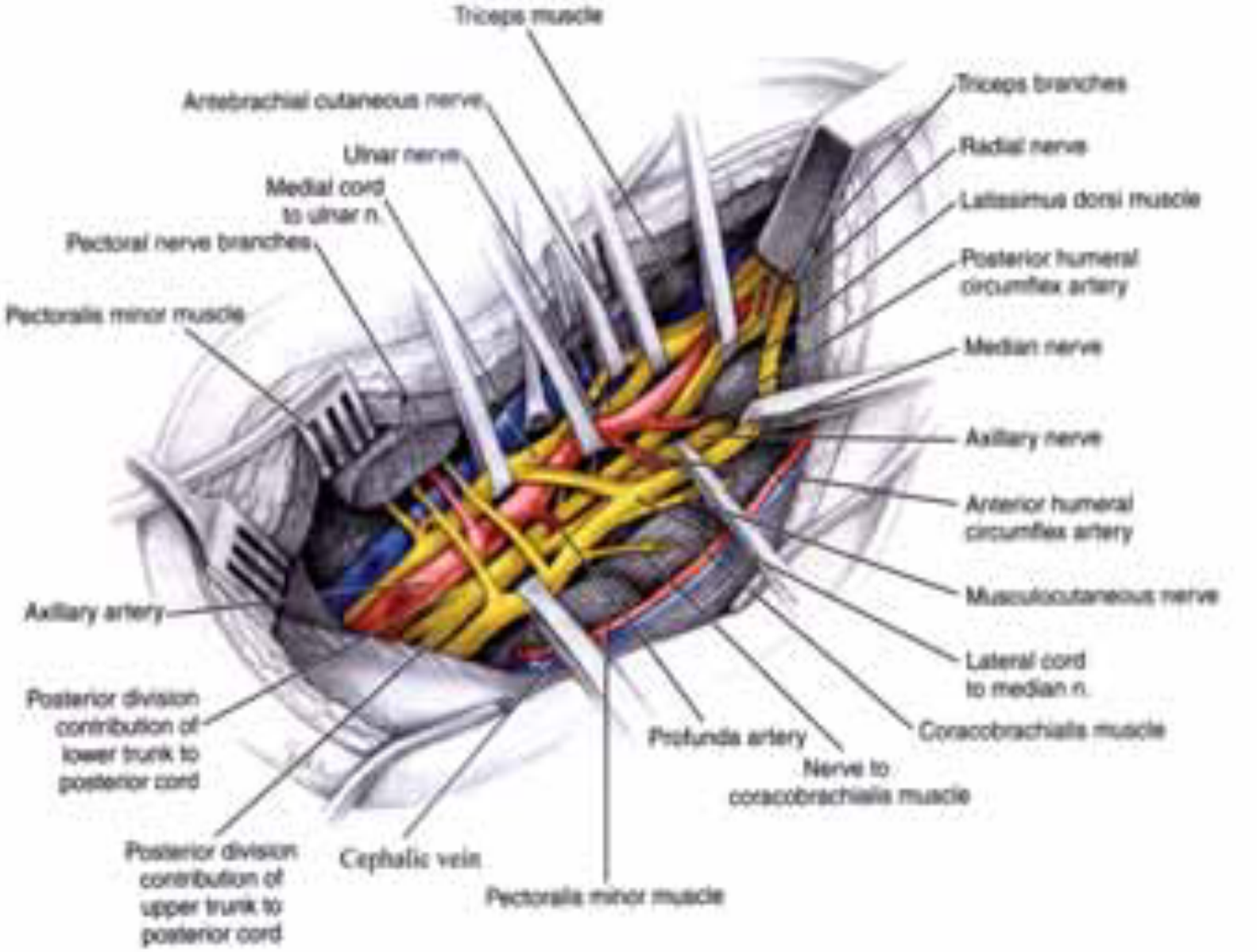




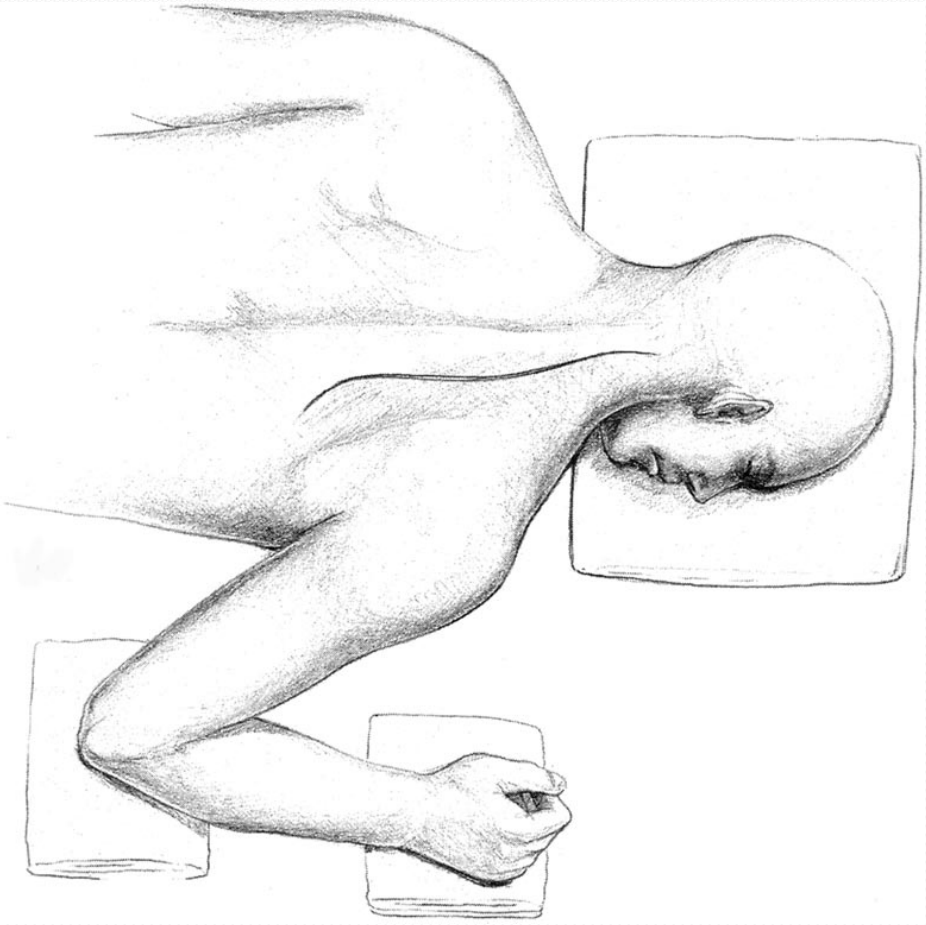
Posterior Cord - Branches



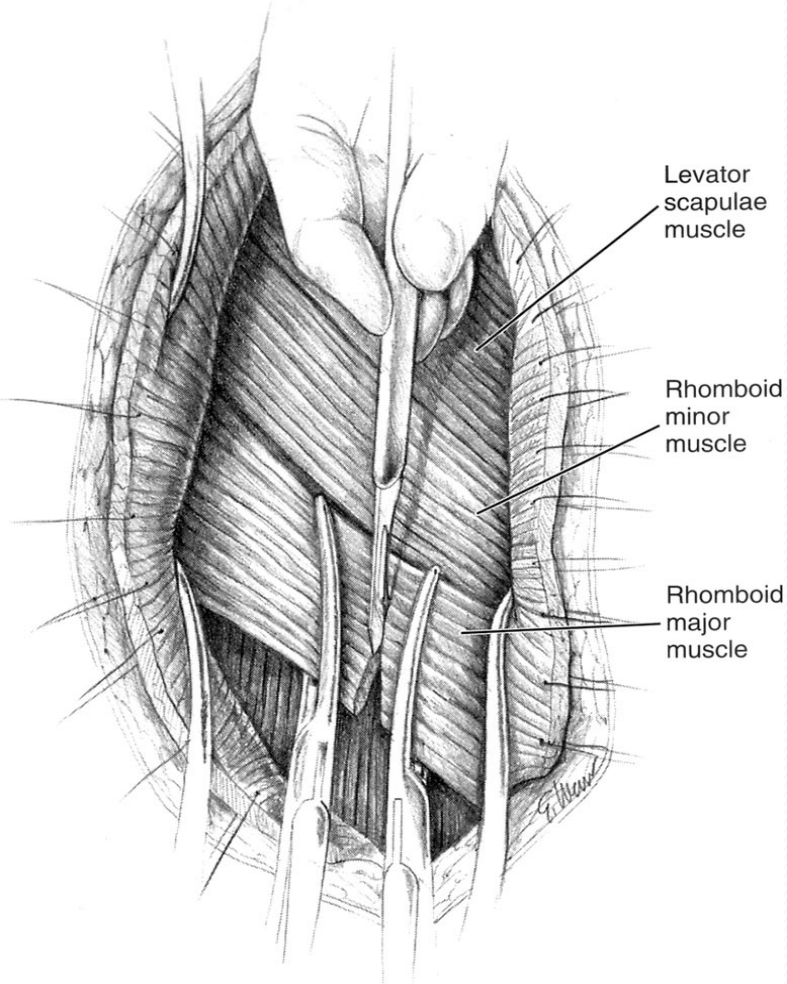
Complete Neurovascular dissection

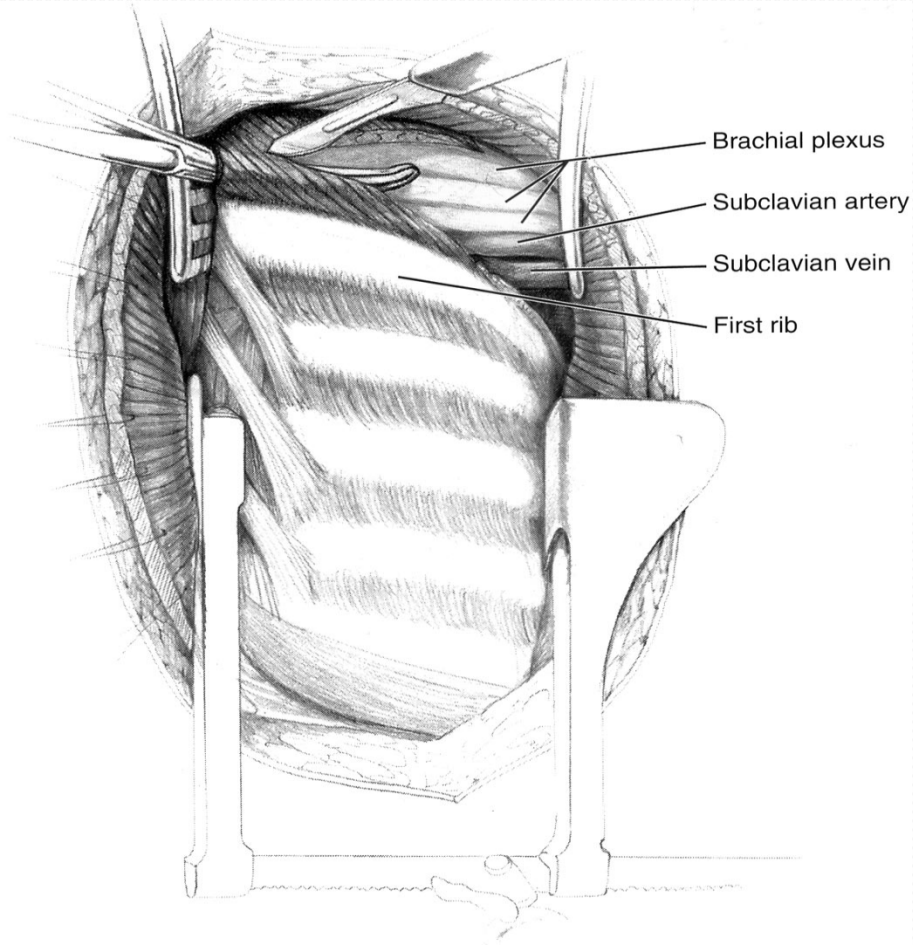


Posterior Approach – Incision

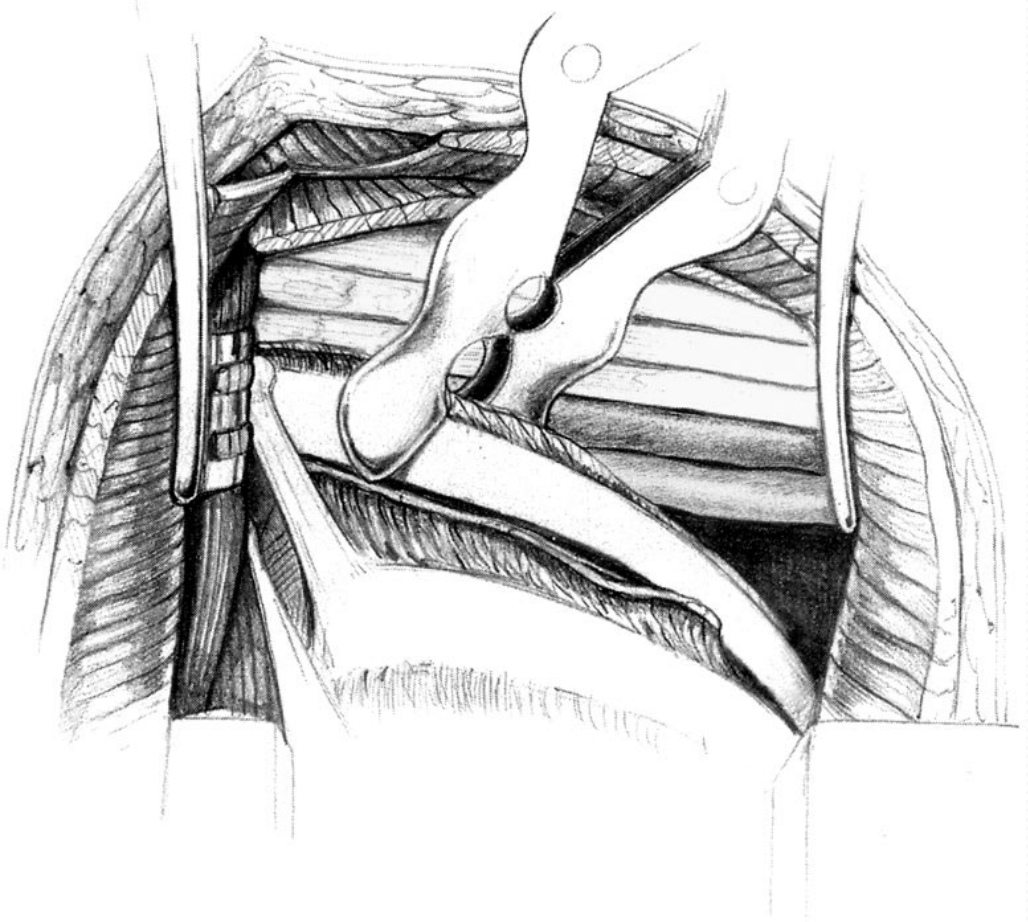


Exposure

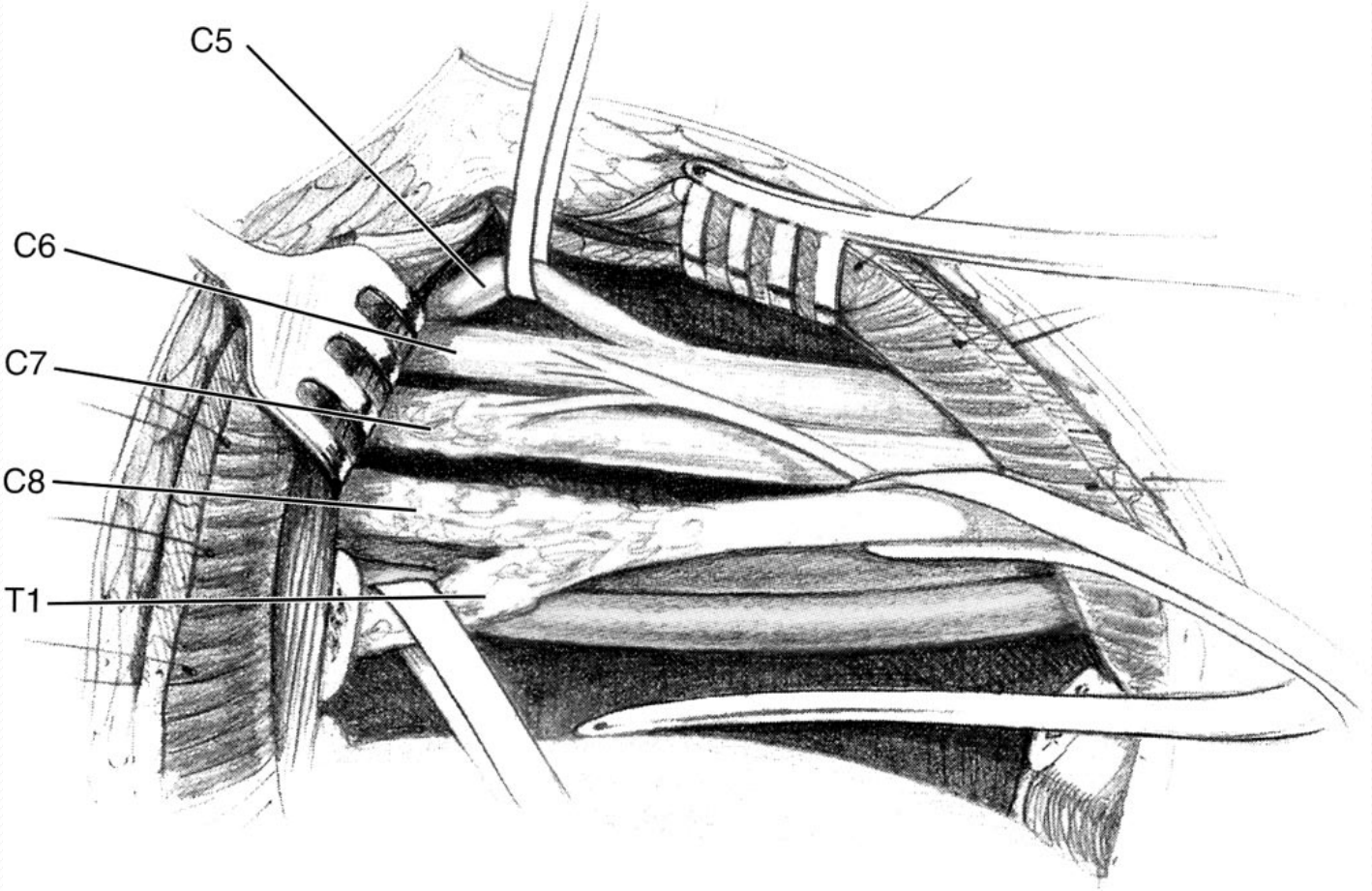

Levator scapulae muscle
Rhomboid minor muscle
Rhomboid major muscle


Brachial plexus
Subclavian artery
Subclavian vein
First rib

Transection of Ist Rib



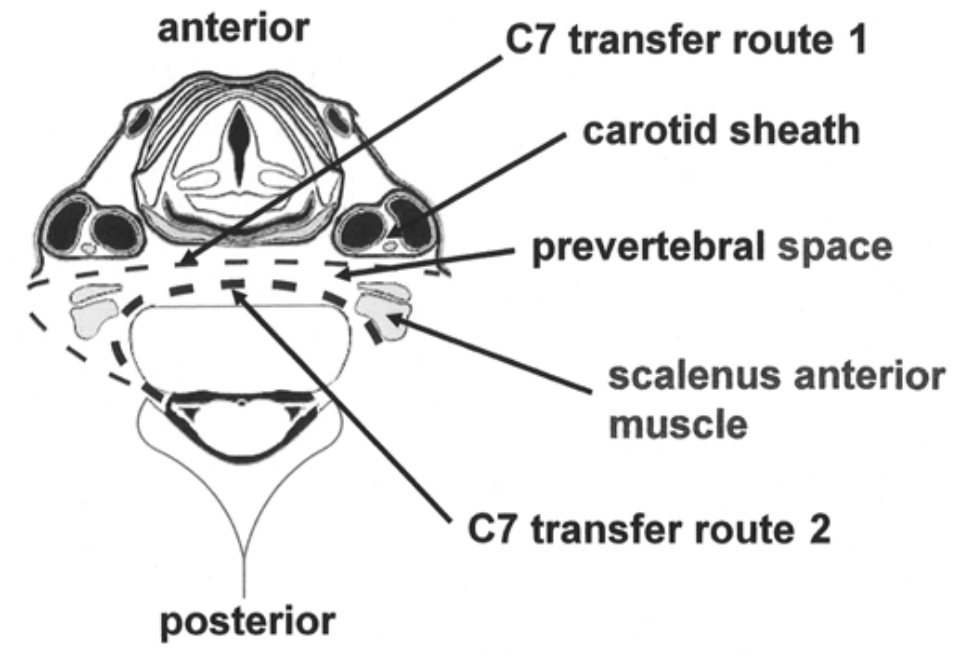
Dissection of Origin of Plexus



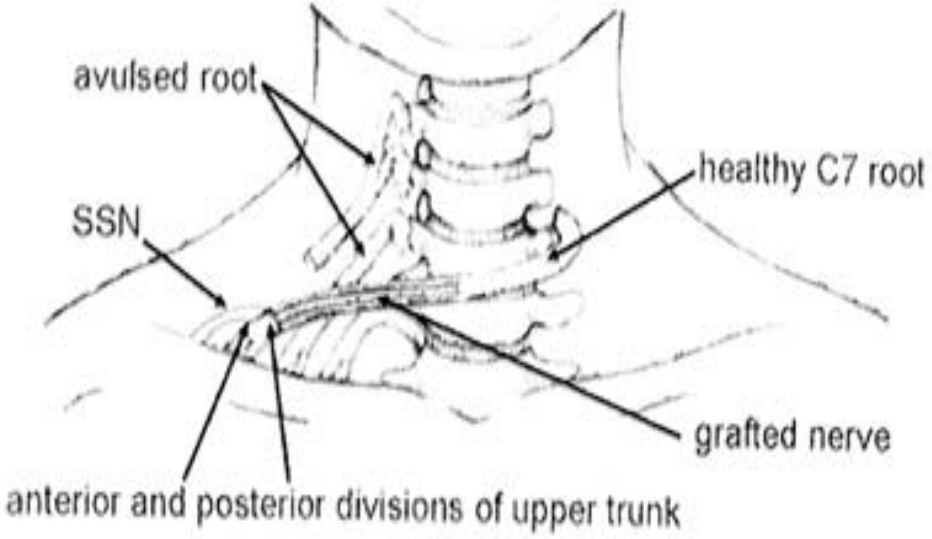
Nerve Transfer

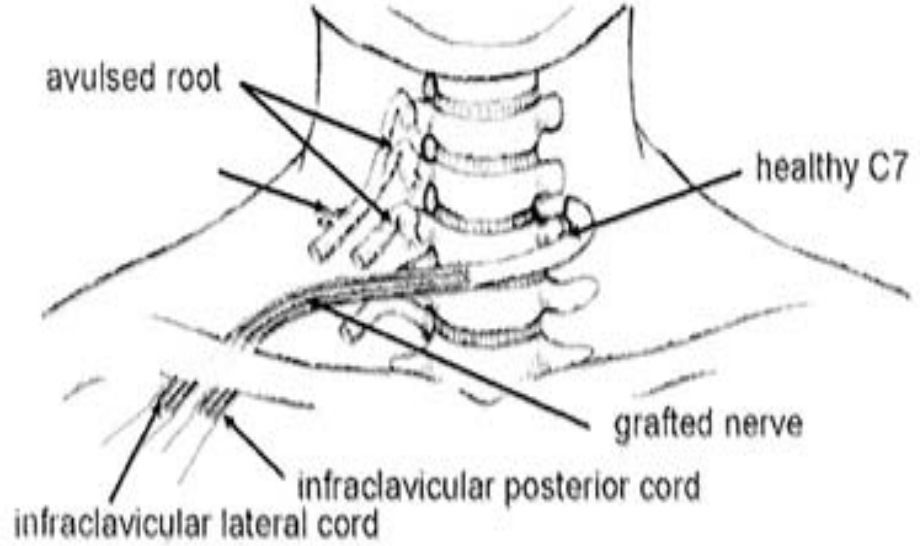
Subject	Donor	Recipient	Remarks
Shoulder Stabilisation	Spinal Accessory	✓Supra-scapular ✓Axillary ✓Radial ✓MCN	1500 myelinated axons Free gracilis muscle transfer
	Radial nerve to triceps – medial head m/c used	✓Axillary nerve (main trunk) ✓Ant. Division axillary nerve	
Elbow Stabilisation	Single Ulnar fascicle	✓Nerve to biceps ✓MCN	Oberlin's transfer – Dominant fascicle to FCU
	Single median nerve fascicle	✓Nerve to biceps ✓MCN	
	Medial pectoral	✓MCN	
	ICN	✓MCN	T3-T5 1200 myelinated axons

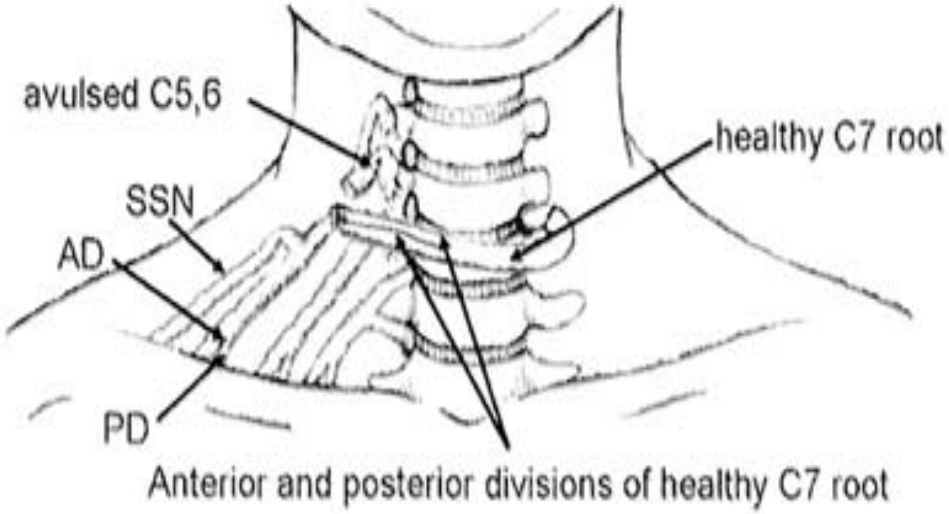
Subject	Donor	Recipient	Remarks
Protective Sensation	Sensory ICN	✓Lateral cutaneous nerve ✓Median nerve	T3-T5
Miscellaneous	Contralateral C7 transfer (Posterior division or at cord level)	✓Upper Trunk ✓C7 nerve root ✓Lateral cord ✓Posterior cord ✓SSN ✓Lower trunk	Gu et al Used in Pan BPI and children Distance reduced by transection of b/l ASM Graft – Sural nerve/ superficial radial nerve



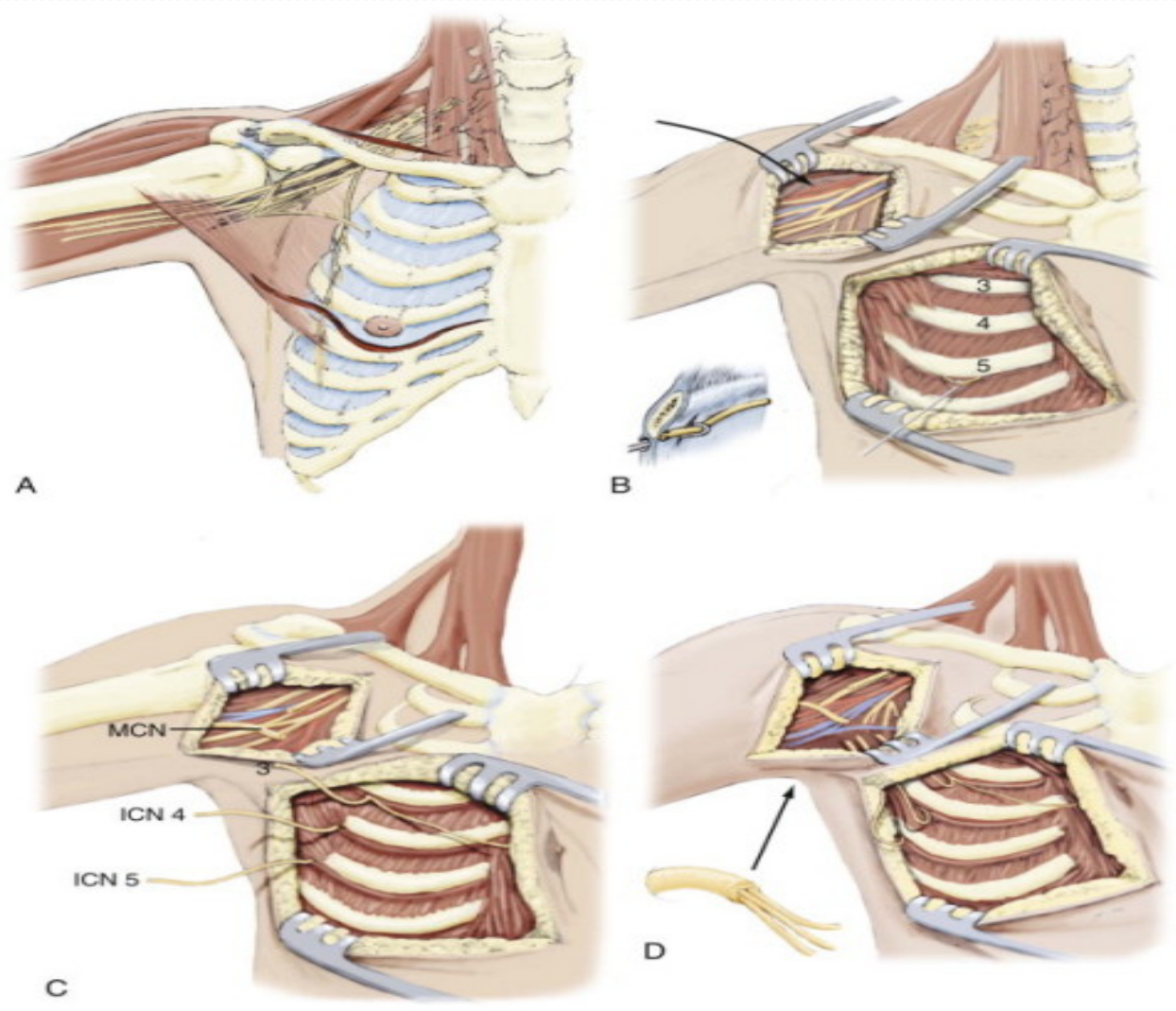
Contralateral C7 transfer







ICN-MCN transfer



Dual Nerve transfer

- Elbow Flexion –
  - Medial pectoral nerve to MCN + UN to N. to Biceps
  - Ulnar fascicle to biceps nerve + Median nerve to N. to Brachialis
- Shoulder Abduction –
  - ✓ Radial nerve (N. to Triceps) to Axillary nerve + SAN to SSN

Results (Kim et al – 2500 BPI)

Injury	Severity	Criteria	% Success (MRC Grade ≥ 4)
Sharp penetrating	Complete	< 72 hrs	87
		> 72	67 (Direct repair)
		> 72	53 (Nerve grafting)
	Incomplete	NAP +	92 (Neurolysis)
		NAP -	77 (1^0 Repair)
Blunt	--	--	45 (Grafting)
Stretch	Root Avulsion +	Single level	Grade IV/V
		Multilevel	Grade III/IV
	Root Avulsion -	---	~ 100 (Neurolysis/Grafting)
Pan BPI	---	---	35 (Overall)
Infra-clavicular	Lateral cord	---	~ 100 (Poorer for other cords)

Injury	Severity	Type of repair	Success %
GSW	Complete	Neurolysis	91
		Direct anastamosis	67
		Graft repair	54
	Incomplete	Neurolysis	94
		Direct anastamosis	83
		Graft repair	54

Results – BRBPI (Malessy et al)

Subject	N	FU (yrs)	Inclusion Criteria	Results
External Rotation	86	3	Surgical reconstruction – SSN C5-SSN / XIN-SSN transfer	20 with true external rotation > 20^0 87 % can reach mouth 75 % can reach back of head
Elbow Flexion	20	2	ICN-MCN / PEC-MCN transfer	86 % elbow flexion ≥ 3 (MRC) PEC - MCN : 93 % ICN - MCN : 81 %
Hand Function	16	3	Reconstruction of C8 & T1	69 % : Raimondi hand score ≥ 3

Outcome After Delayed Oberlin Transfer in Brachial Plexus Injury (Neurosurgery - 2011)‡

- Retrospective – 9 patients
- Av. Duration between trauma and Sx – 12.2 mo
- Av. FU – 26.7 months
- Biceps power pre-op -0/5 and post-op ≥ 2/5 all pts
- 77.8 % gained useful power ≥ 3/5 MRC grading

‡ Sedain G, Sharma MS, Sharma BS, Mahapatra AK

Secondary Procedures

- Muscle/tendon transfer
- Functioning free muscle transfer
- Arthrodesis
- Tenodesis
- Corrective osteotomy

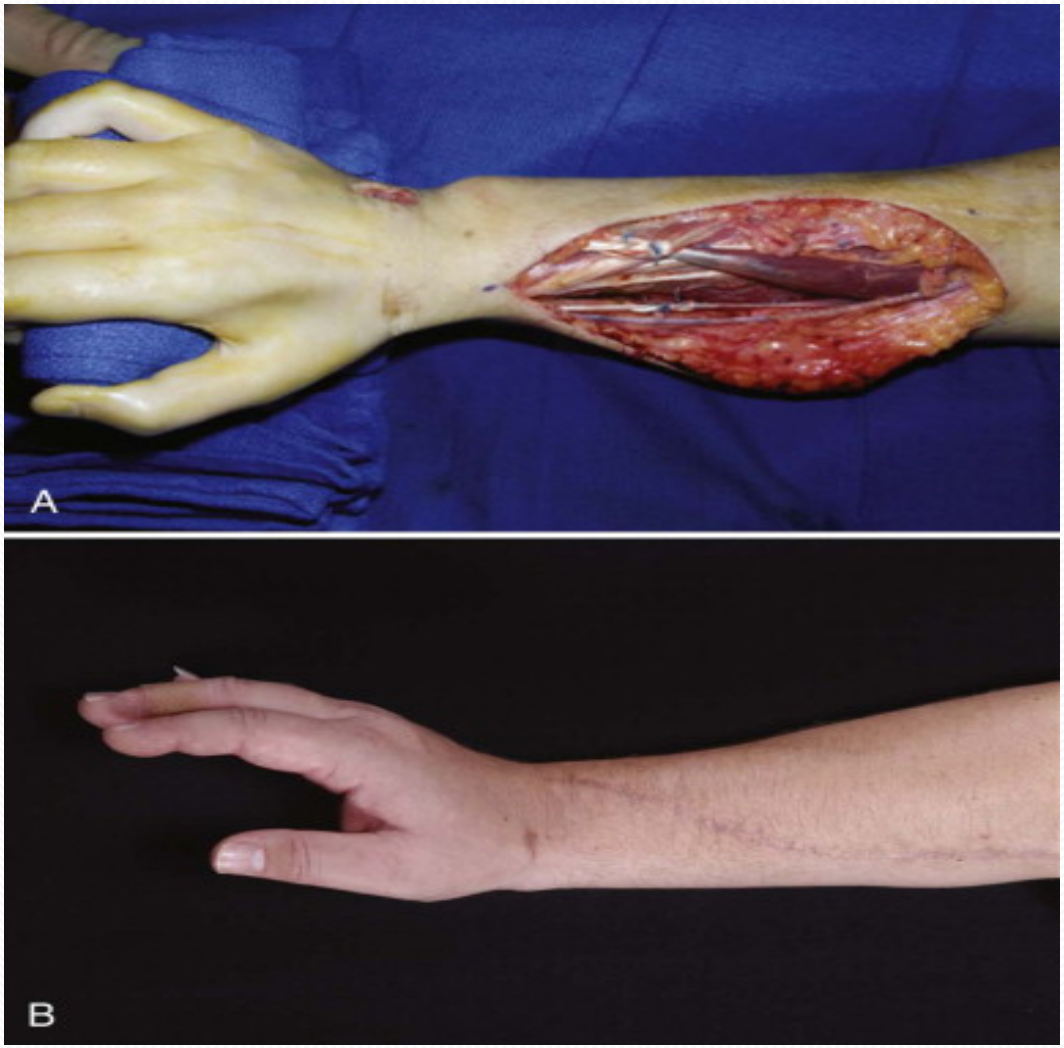
Tendon Transfer – General principles

- Tissue Equilibrium – Wounds well healed and contractures corrected
- Availability
- Muscle Strength – MRC ≥ 4/5
- Excursion – Amplitude of range of motion similar
- Direction – Direct line of action without angulations
- Synergy – Difficult to provide in BPI
- Tension – Slightly more than resting muscle length

Tendon Transfer - Options

Joint	Procedure	Remarks
Shoulder	Trapezius to proximal humerus	Improves shoulder abduction and flexion each by about 60^0
	Latissimus dorsi or Teres major	Used in BRBPI mainly Inferior results in adults
Elbow	Latissimus dorsi myo-cut. flap	Limited role in extensive UT+MT BPI
	Pectoralis major transfer	Used in extensive UT+MT BPI Limited role for females
	Steindler's Procedure	Augmentative procedure
	SCM	Unacceptable cosmetically
Wrist	Flexor carpi ulnaris/Flexor carpi radialis	Brachialis is used only if forearm muscles not suitable
	Flexor digitorum superficialis	
	Pronator teres	

Wrist Stabilisation



FFMT – Elbow function

- Gracilis harvested from pubic symphysis and pes anserinus along with neurovascular bundle
- Proximal pole anchored to clavicle
- Vascular anastamosis – Thoraco-acromial to Branch of profunda femoris
- Neurotisation – SAN/ICN to obturator nerve
- Distal pole of gracilis secured to biceps tendon in mid-flexion

FFMT – Prehensile function

- Gracilis transfer – Finger flexion
- Origin – IInd rib / Clavicle
- Insertion – FDP and FPL
- Passed under pronator teres – Pulley effect
- Neurotisation – ICN to Obturator
- Anastamosis – Thoraco-dorsal vessels to profunda femoris
- Graft tensioned – Finger extension during elbow flexion and vice-versa

Elbow fn.

Prehensile fn.

FMT – Double functioning

- Useful in Pan BPI

- Two Stage procedure –

Stage I

- Nerve reconstruction for shoulder
- FMT using gracilis for elbow flexion + wrist or finger extension

Stage II

- Two ICN – Neurotisation to IInd gracilis FMT for finger flexion
- Another two ICN for triceps
- Sensory ICN to Lateral cord (Median nerve) for hand sensation

❖ Doi et al – results

✓ Good to excellent elbow flexion – 96 %

✓ > 30^0 of active finger flexion – 65 %

Arthrodesis – Joint Fusion

- Shoulder – Requirements

- Intact Scapulo-thoracic mobility
- Preserved Trapaezius, levator scapulae, serratus anterior and rhomboid muscle function

- Optimal position – 30^0 abduction, forward flexion and internal rotation
- Practical measurement – Pt able to get their hand to mouth while maintaining abduction position

- Wrist arthrodesis –
  - Weakens power grip
  - Kept as last resort

- Hand arthrodesis –
  - Mainly for thumb
  - CMC or IP joint fusion done

Tenodesis

- Tends to relax secondarily and lose its function
- Most common – Wrist to stabilise it in functional position

- Performed when suitable tendon transfers are un-available –
  - Weak wrist flexors not suitable for transfer
  - Tenodesis of antagonistic muscles like finger extensors
  - Helps open the fingers while actively flexing wrist
  - By dynamic tenodesis effect

Corrective Osteotomy

- Elbow flexion +nt but active external rotation –ve
- Inwardly rotated arm with hindrance to elbow motion
- Transverse osteotomy of middle 1/3 rd humerus
- Distal part of humerus rotated 30-60^0 outside
- Fixed using dynamic compression plate
- Commonly performed in BRBPI

Amputation/Prostheses

- Indication –

  - Failed reconstruction with upper limb
  - Nuisance or mechanically painful
  - Potential hazard for injury
  - Mechanical pain from shoulder subluxation

- Trans-Humeral amputation –

  - Relieves mechanical subluxation pain
  - No relief from neuropathic pain

- Mid-forearm amputation / Wrist disarticulation –

  - Insensate digits – multiply traumatised

Recent Advances

- Neural conduits +/- Nerve growth factors
- Stem-cells – BM-MNCs and MSCs transplantation
- Direct Nerve root transfer - Intraplexal
- Nano-scale engineered devices - Microanastamosis
- Electrical stimulation guided neural growth
- Gene Therapy

Comment made by Sir Sydney Sunderland-1951

“ It is no longer a question of what can be done, but of establishing what should be done”