SIRVA

Shoulder Injury Related to Vaccine Administration

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I have NO RELEVANT financial disclosures

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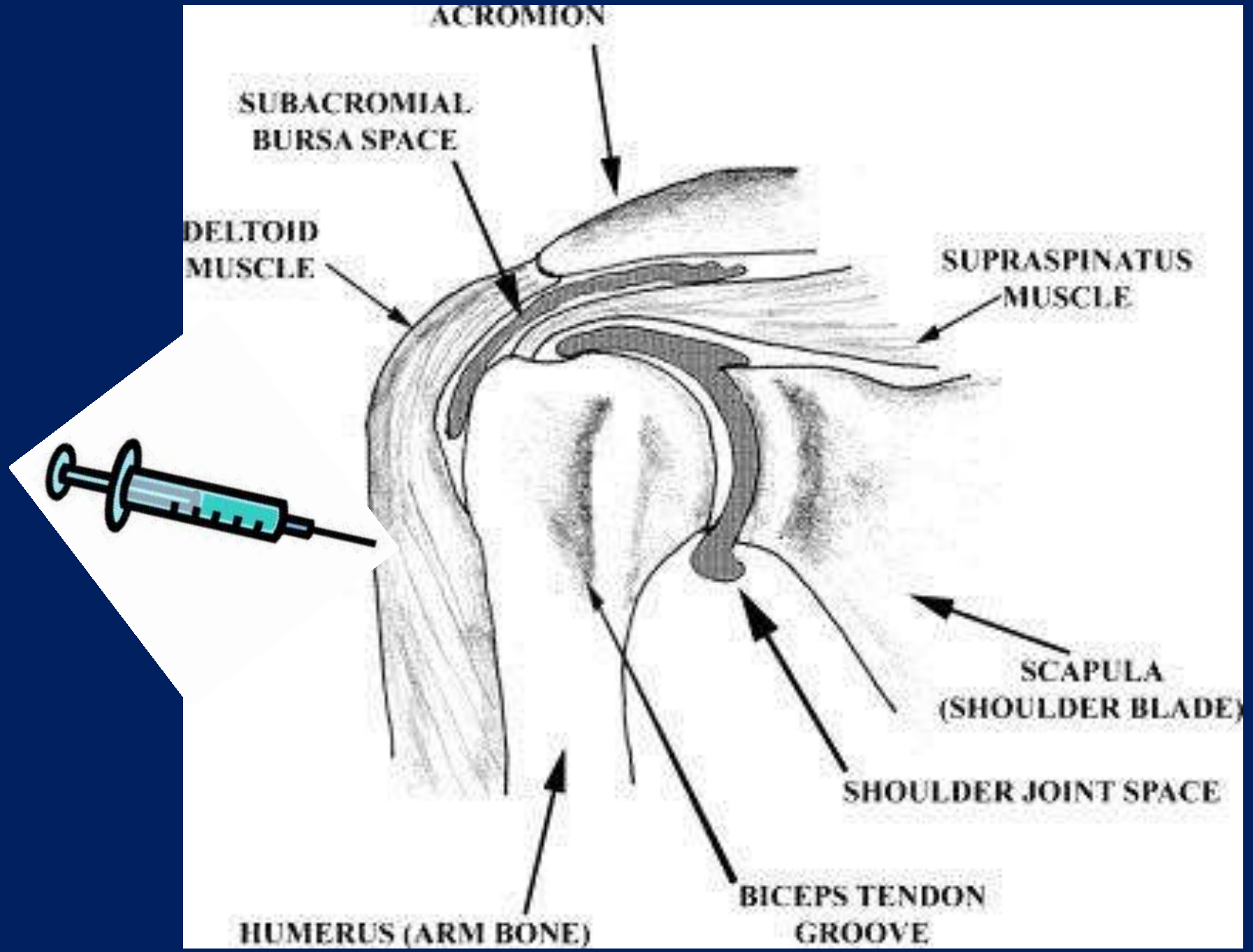
Primum non nocere

- Given the large number of injections, complications are rare.
- A healthy person agreeing to a benign, preventive minor procedure has high expectations of a successful outcome.
- What is preventable and what is not?
- Complications

  Musculoskeletal – capsulitis, tendinitis, bursitis, periosteum

  Neurologic – individual nerve injuries & neuralgic amyotrophy
- Will not discuss allergic reactions, localized inflammatory reactions, infections, transient febrile episodes.


ACROMION
SUBACROMIAL
BURSA SPACE
DELTOID
MUSCLE
SUPRASPINATUS
MUSCLE
SCAPULA
(SHOULDER BLADE)
SHOULDER JOINT SPACE
BICEPS TENDON
GROOVE
HUMERUS (ARM BONE)

Different Injection Techniques

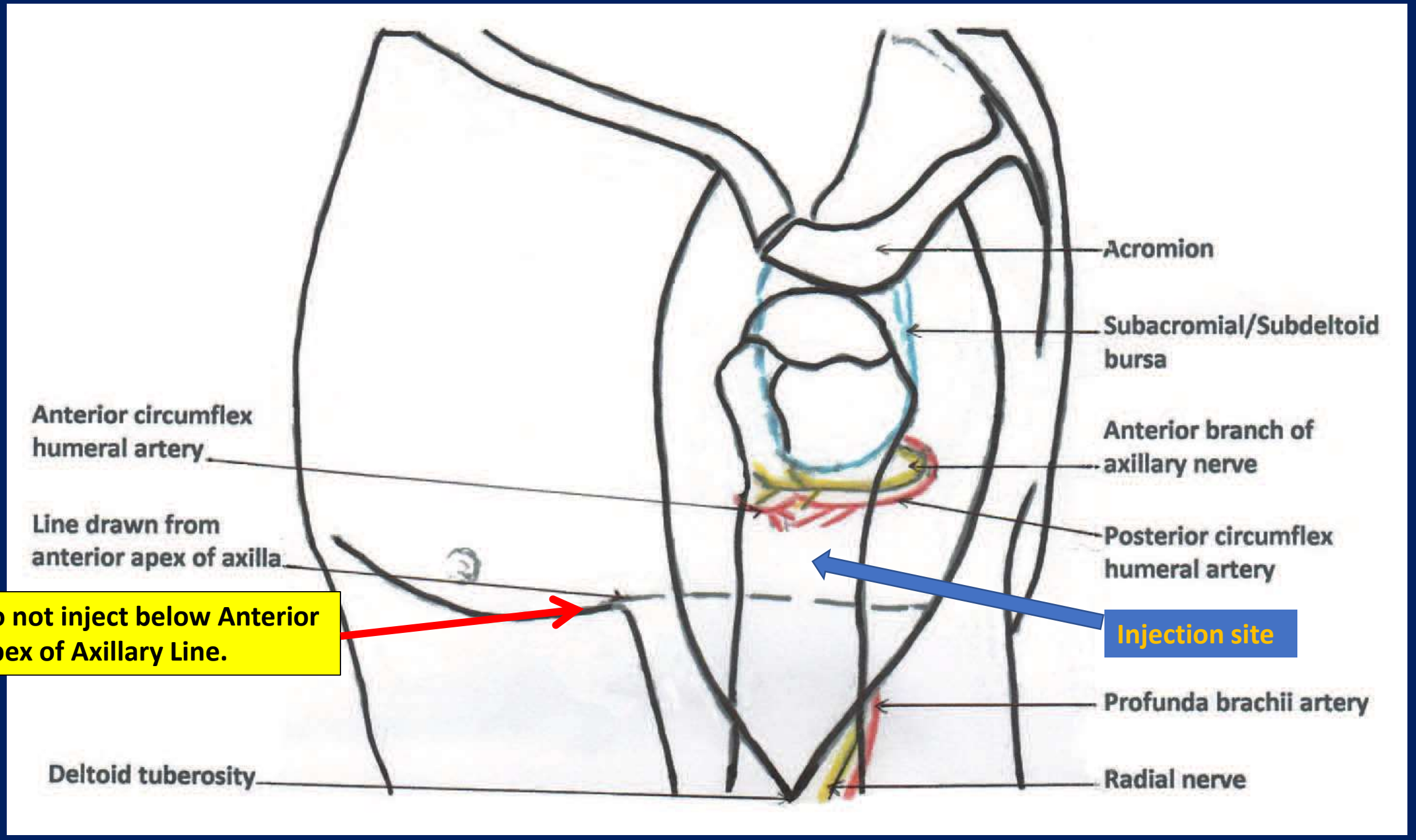
1. Injection given variable distances below acromion measured as centimeters or finger breadths.
2. Injection is given into the midpoint of a triangle formed by acromion and a line drawn laterally from the apex of the anterior axilla across the deltoid muscle, approximately 2 or 3 finger breadths below the acromion.
3. Injection midway between the acromion and the deltoid tuberosity
4. Injection into the middle third of the deltoid muscle

Deltoid Injection Localization Techniques

Cook, 2011

Method	Distances of Injection from Mid-acromion (mid-way from tip of acromion to deltoid tuberosity
1.	1 to 5 cm
2.	4.0 to 5.8 cm male; 3.5 to 4.8 cm female
3.	2.25 to 7.0 cm male; 4.1 to 6.0 cm female 6.5 to 8.0 cm male; 6.5 to 7.2 cm female
4.	4.5 to 5.6 cm male; 3.7 to 4.8 cm female 9.0 to 11.2 cm male; 7.4 to 9.6 cm female
5.	6.8 to 8.5 cm male; 5.5 to 7.3 cm female

Variability 1 to 11.2 cm


Acromion
Subacromial/Subdeltoid bursa
Anterior branch of axillary nerve
Posterior circumflex humeral artery
Anterior circumflex humeral artery
Line drawn from anterior apex of axilla
Do not inject below Anterior Apex of Axillary Line.
Injection site
Profunda brachii artery
Deltoid tuberosity
Radial nerve

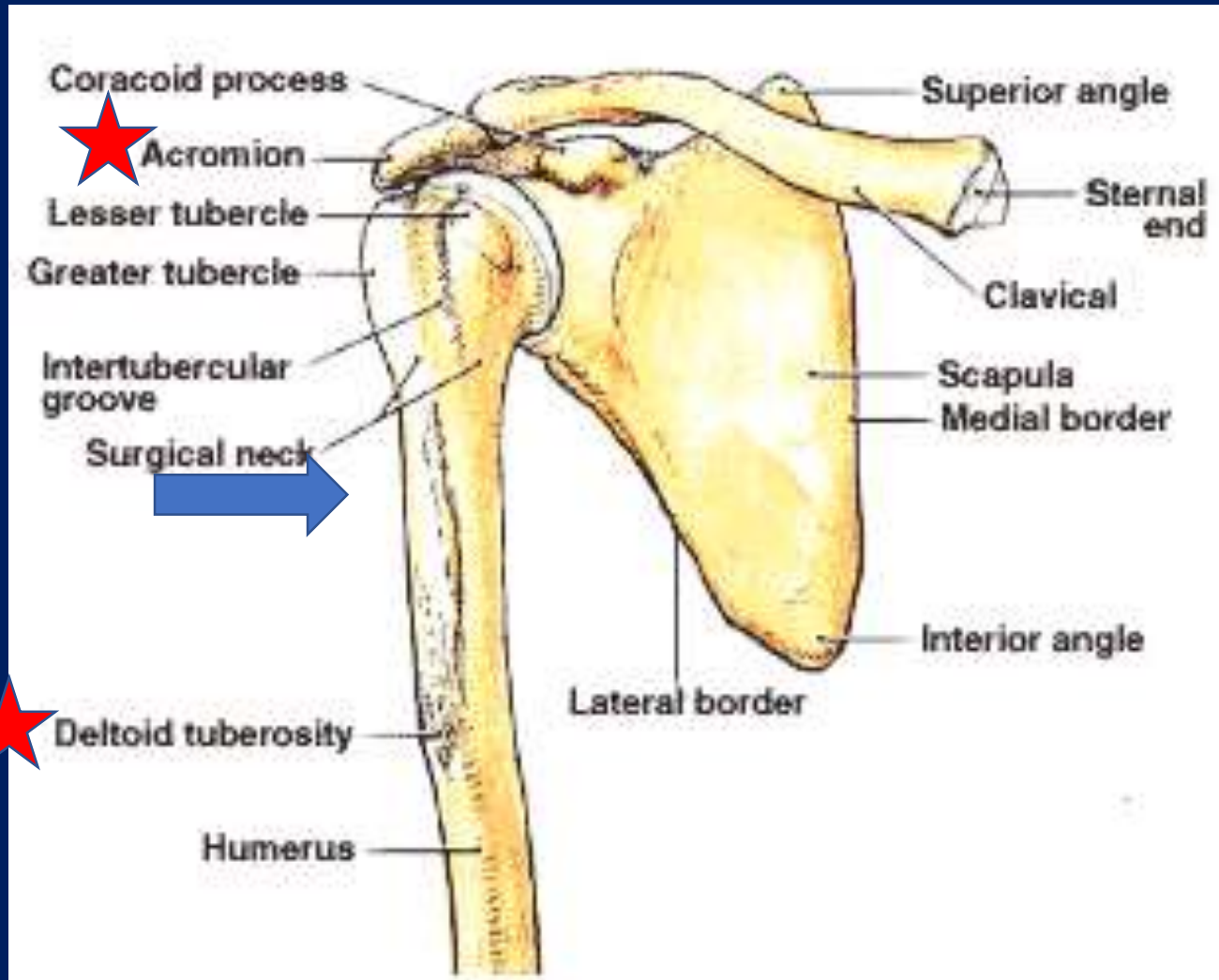
Safe Injection Technique

Cook, 2011; Cook, 2014

- Anthropometric study: 536 patients (283 males, 253 females), ≥ 65 yo

Abduction shoulder to 60°, placing hand on the ipsilateral hip

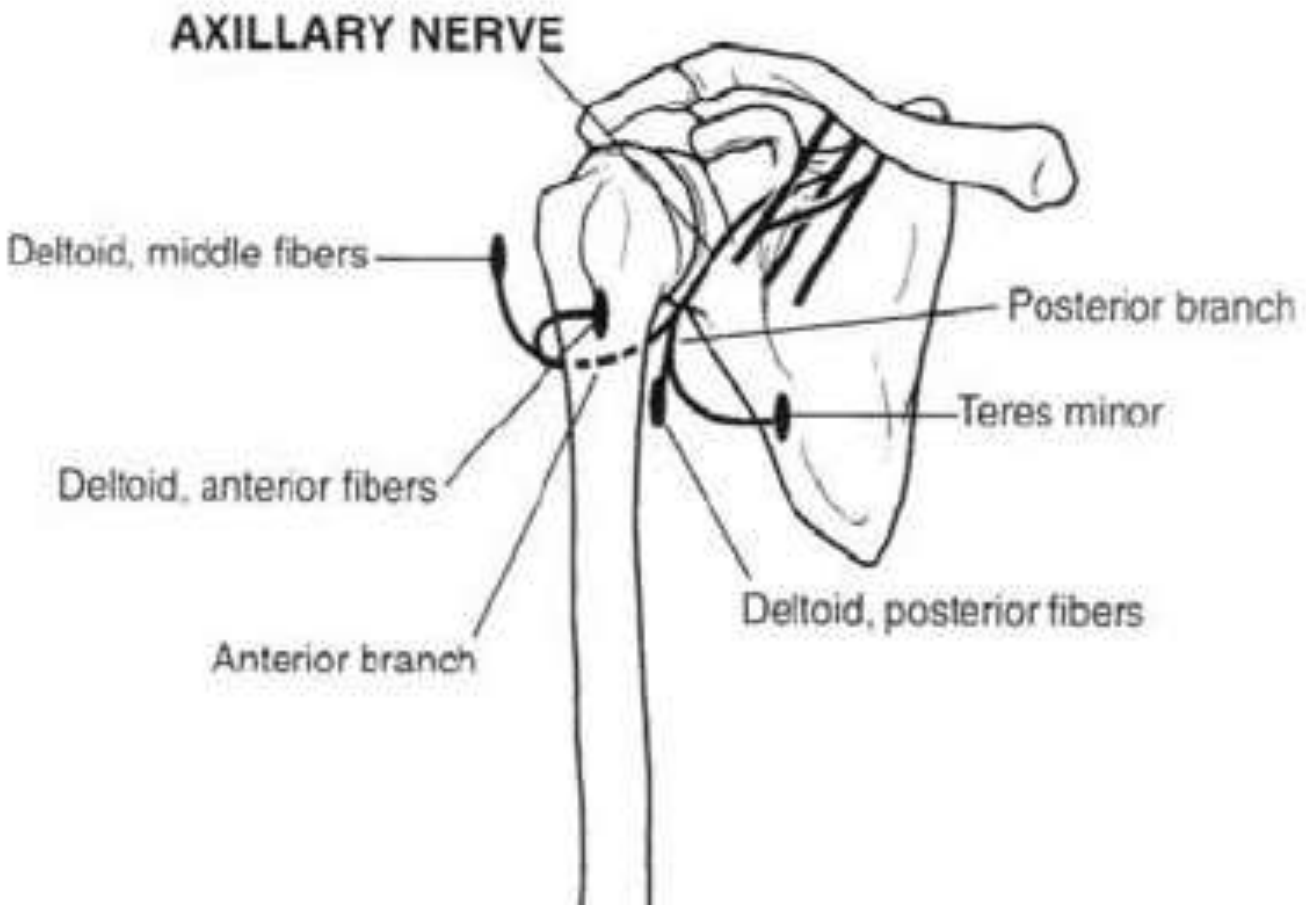
Inject at <u>midpoint</u> between acromion and deltoid tuberosity

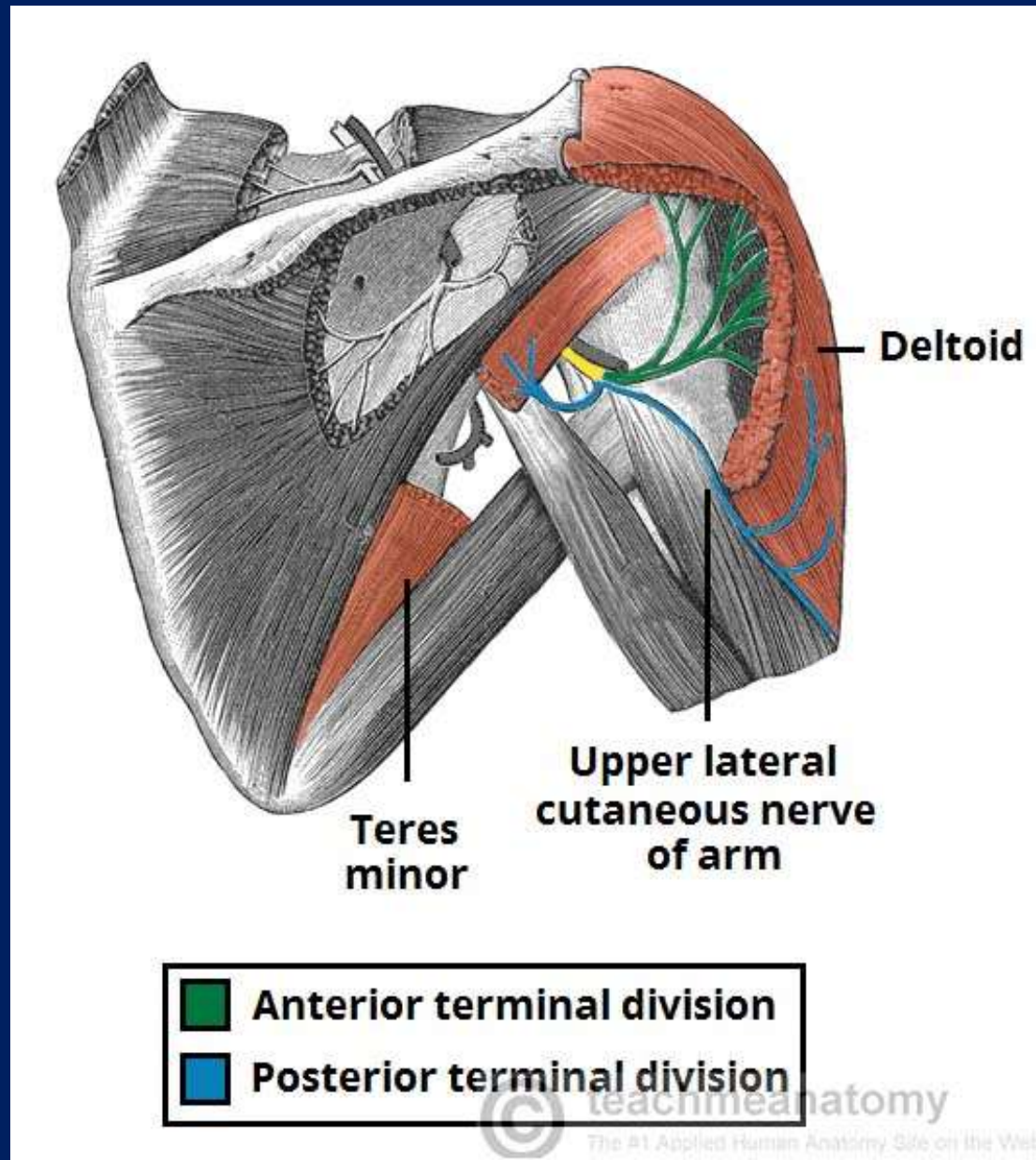


Injection above midpoint of acromion & deltoid tuberosity potential injury to

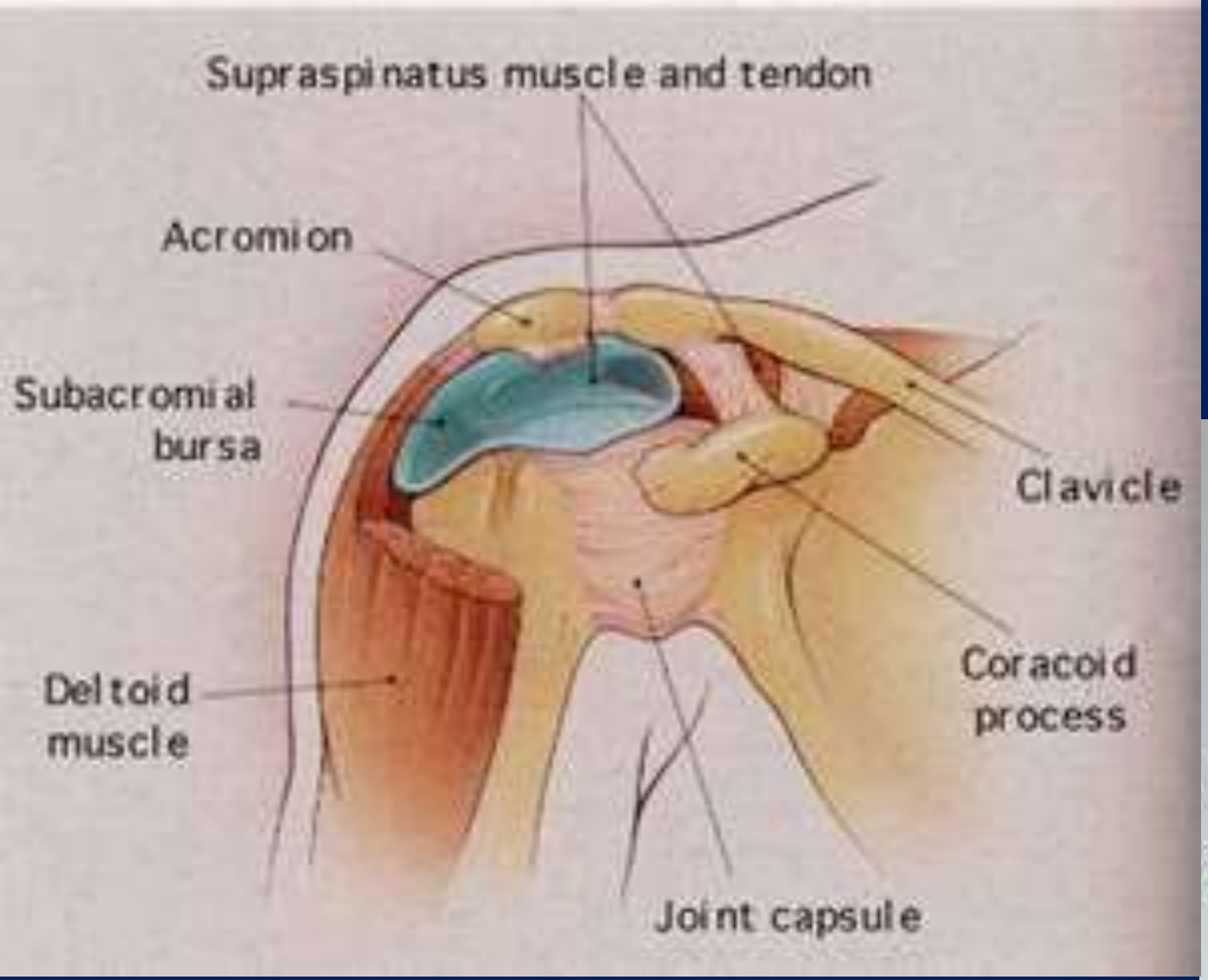
Anterior branch of axillary nerve

Subacromial/Subdeltoid bursa

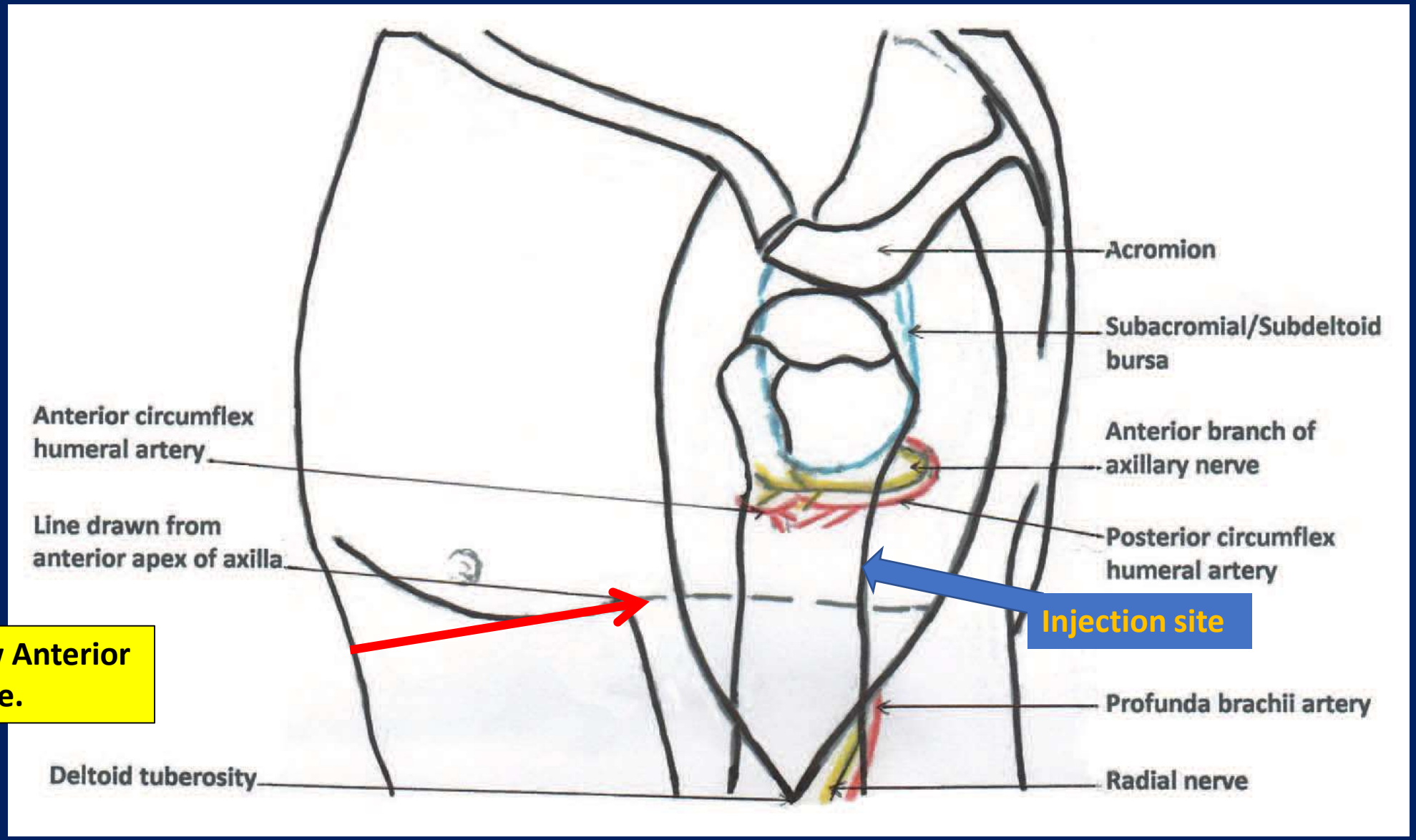




Subacromial (Subdeltoid) Bursa



Avoid injecting below apex of anterior axillary line:
Radial nerve & Avascular musculotendinous insertion

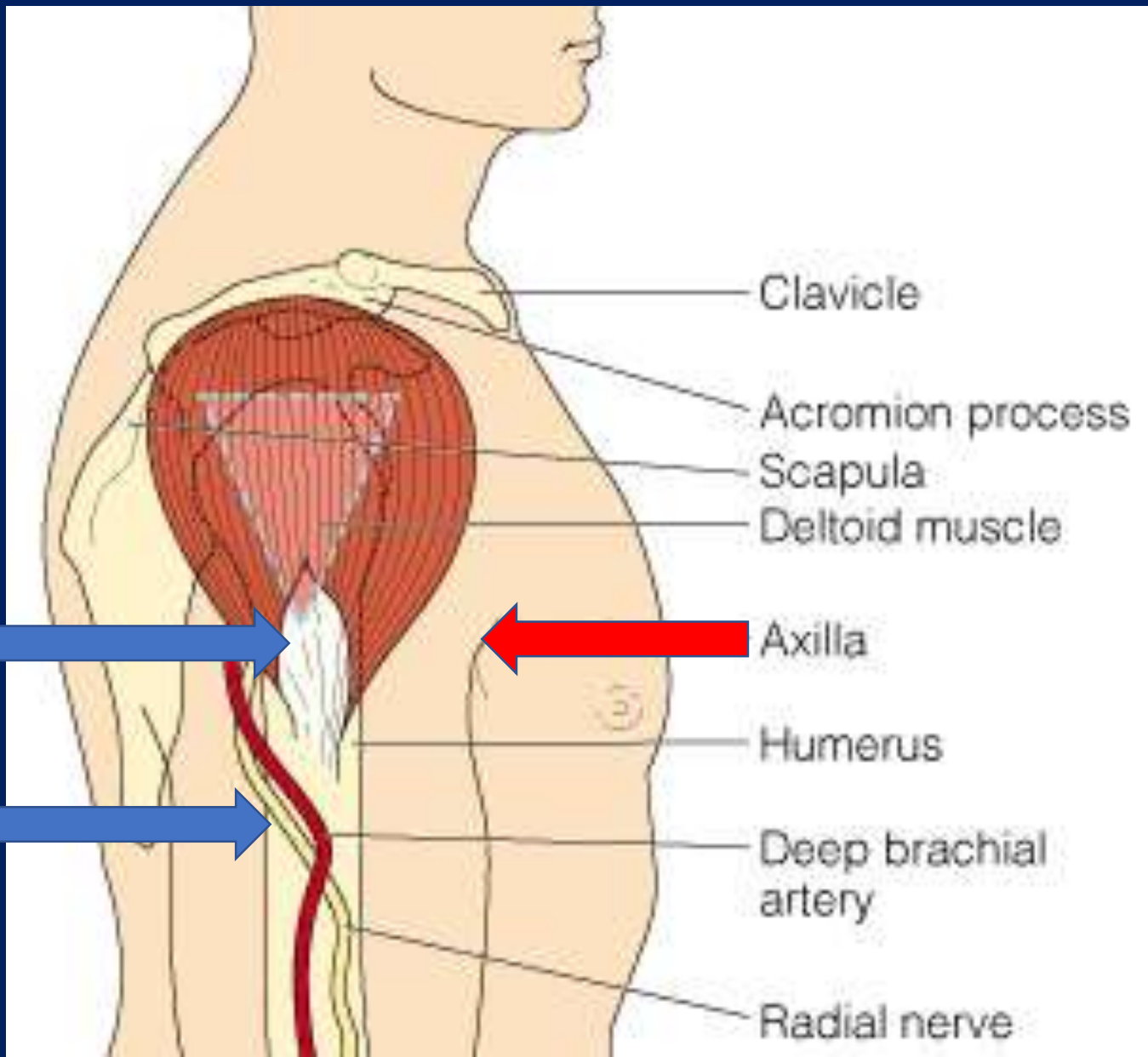


Do not inject below Anterior Apex of Axillary Line.

Avoid injecting below apex of anterior axillary line

Avasc. musculotend. insertion

Radial nerve



Midway between acromion and deltoid tuberosity with arm abducted to 60° is a safe

Acromion

Apex Anterior Axillary Line

Deltoid tuberosity

Depth of Needle Insertion

Cook, 2015

- A 25 mm long needle inserted to hub at 90 degrees penetrates 5mm deltoid m.

  Males < 118 kg with BMI < 35

  Females 60–90 kg with BMI < 35

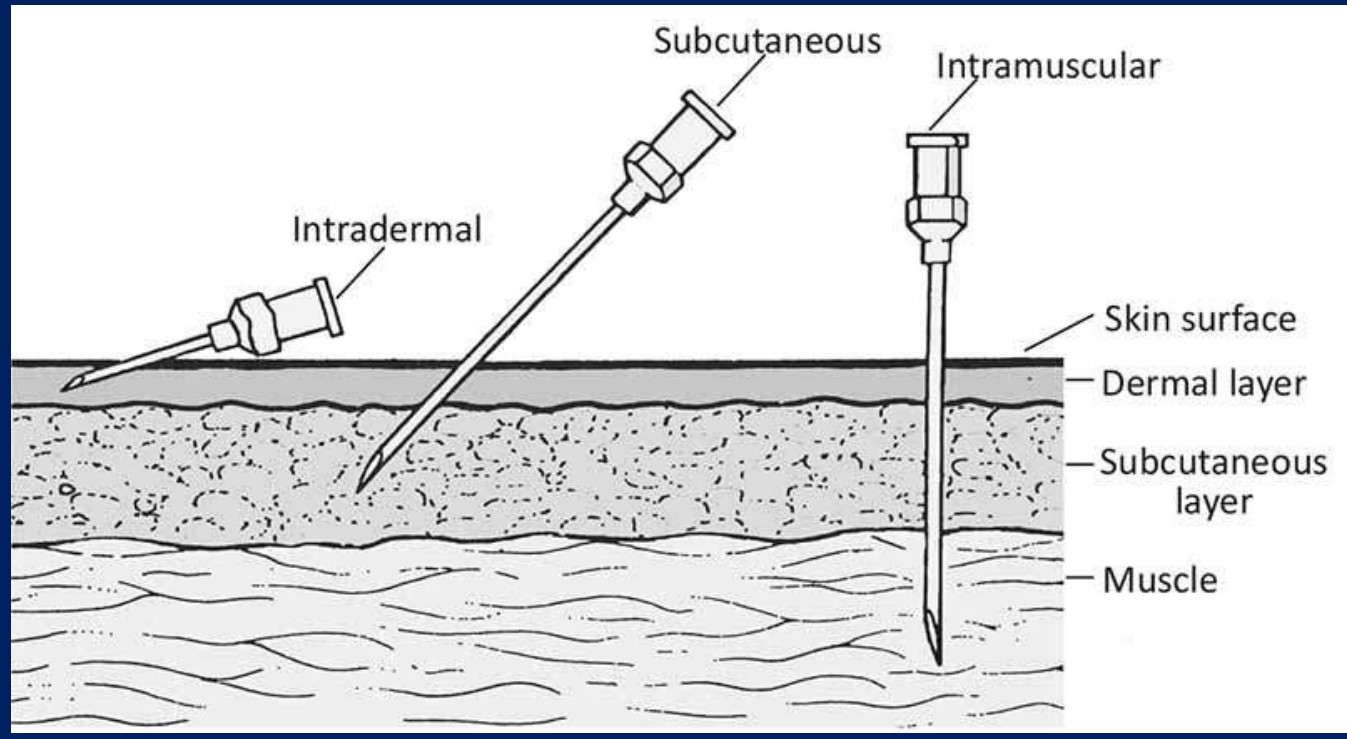
under penetration

  Males > 118 kg with BMI > 35

  Females > 90 kg and BMI >35

over penetration

  Females <60 kg



- Vaccine Adverse Events Reporting System (VAERS) database
  MRI confirmed bursitis/tendinitis: 16 females, 1 male

Influence of skin-to-muscle and muscle-to-bone thickness on depth of needle penetration in adults at the deltoid intramuscular injection site Shankar, et al., 2012

- Measured skin-to-muscle (**adipose**) and muscle-to-bone (**muscle**) thickness
- 100 male and 100 female Indian subjects; Average BMI 24.2 ± 4.9

BMI correlates with shoulder adipose thickness in multiple studies.

Significant Ultrasound Findings

- Females vs. Males: higher adipose thickness & lower muscle thickness
- Right (majority dominant) shoulder = higher muscle thickness
- Left shoulder = higher adipose thickness

Assuming 25 mm needle (and success is ≥ 5 mm muscle penetration)

- Under penetration in 1% subjects; over penetration in 50% subjects

Hypothesis for mechanical shoulder injuries

- Injection leads to a “robust local immune and inflammatory response”

  Subacromial bursitis, Bicipital tendonitis, and Inflammation of shoulder capsule (Adhesive capsulitis)

  Bodor and Montalvo, 2006; Cook, 2015

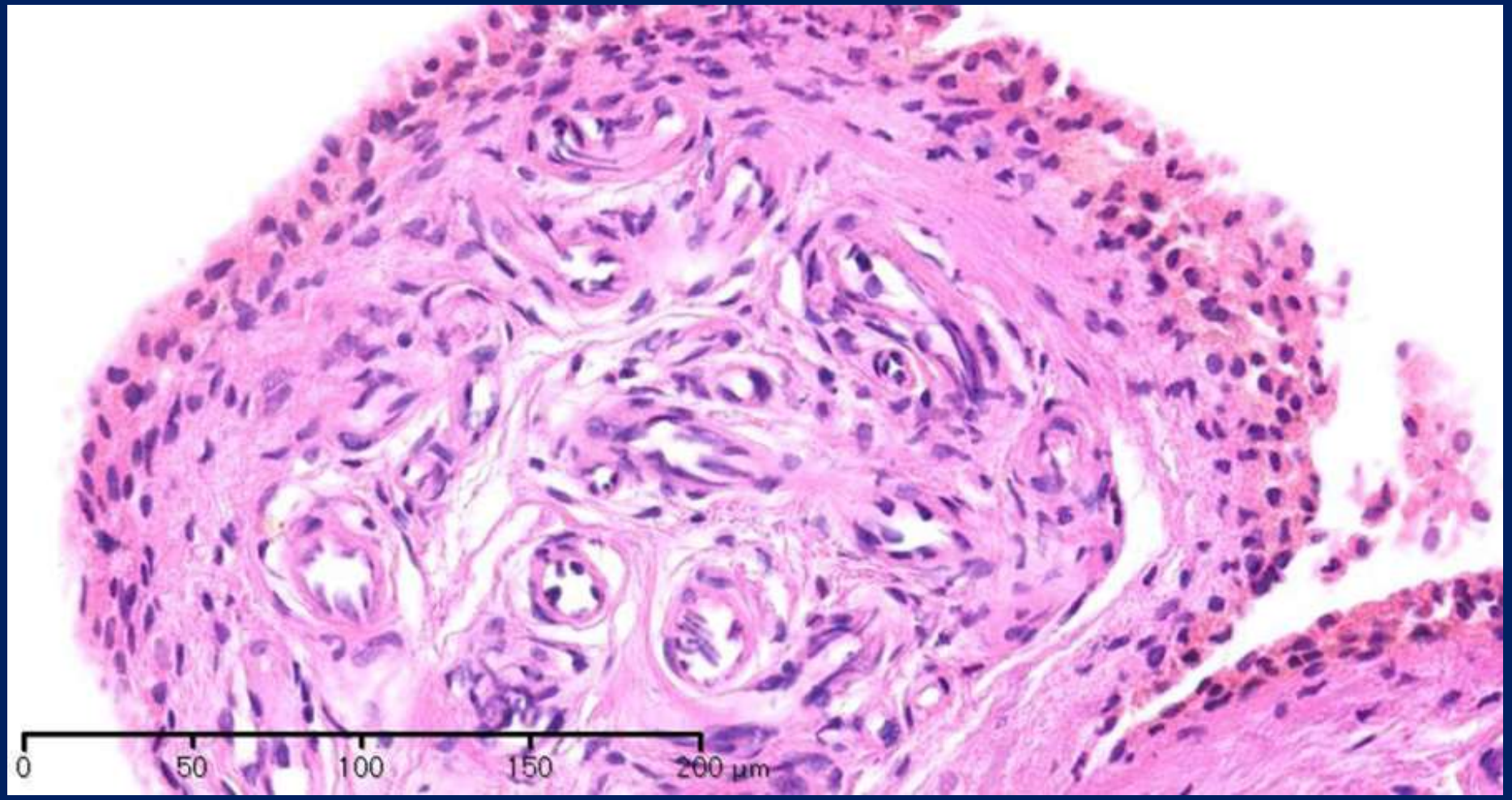
- Periosteal reactions and osteonecrosis reported

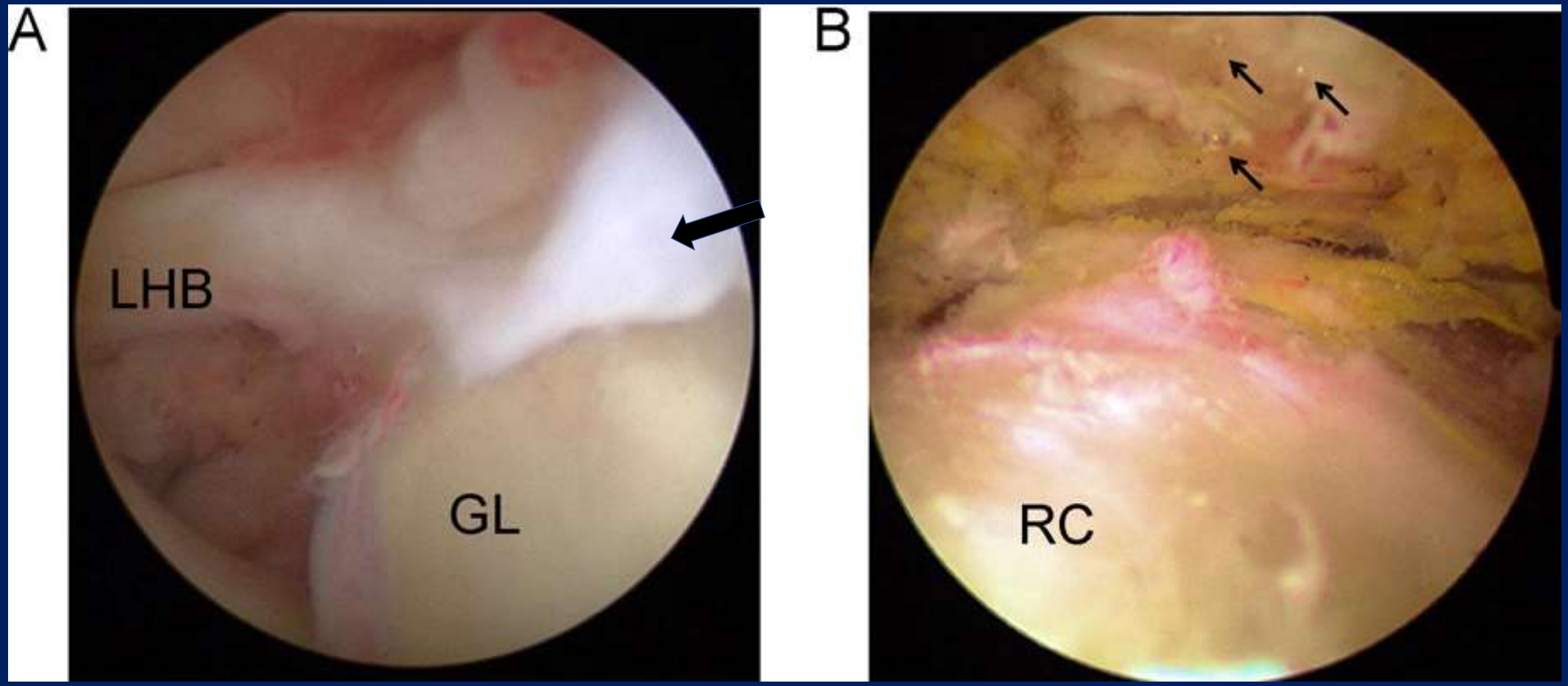
  Cook, 2015

Subachromial bursitis – synovial tissue inflammatory infiltrate and granulation tissue with mild fibrosis

Uchida, et al., 2012

Subachromial bursitis after mis-injection with human papilloma virus vaccine





(A) proliferating synovitis surrounding the superior portion of the glenohumeral joint;

(B) hypertrophic synovitis in subacromial bursa
(LHB, long head of biceps; GL, glenoid; RC, rotator cuff) *Uchida, et al., 2012*

Traumatic Peripheral Nerve Injuries due to Injections

- Radial nerve palsy – passes obliquely to upper humerus proximal to / in spiral groove

2nd most common traumatic inj. in develop countries

Wrist drop, extensor weakness,

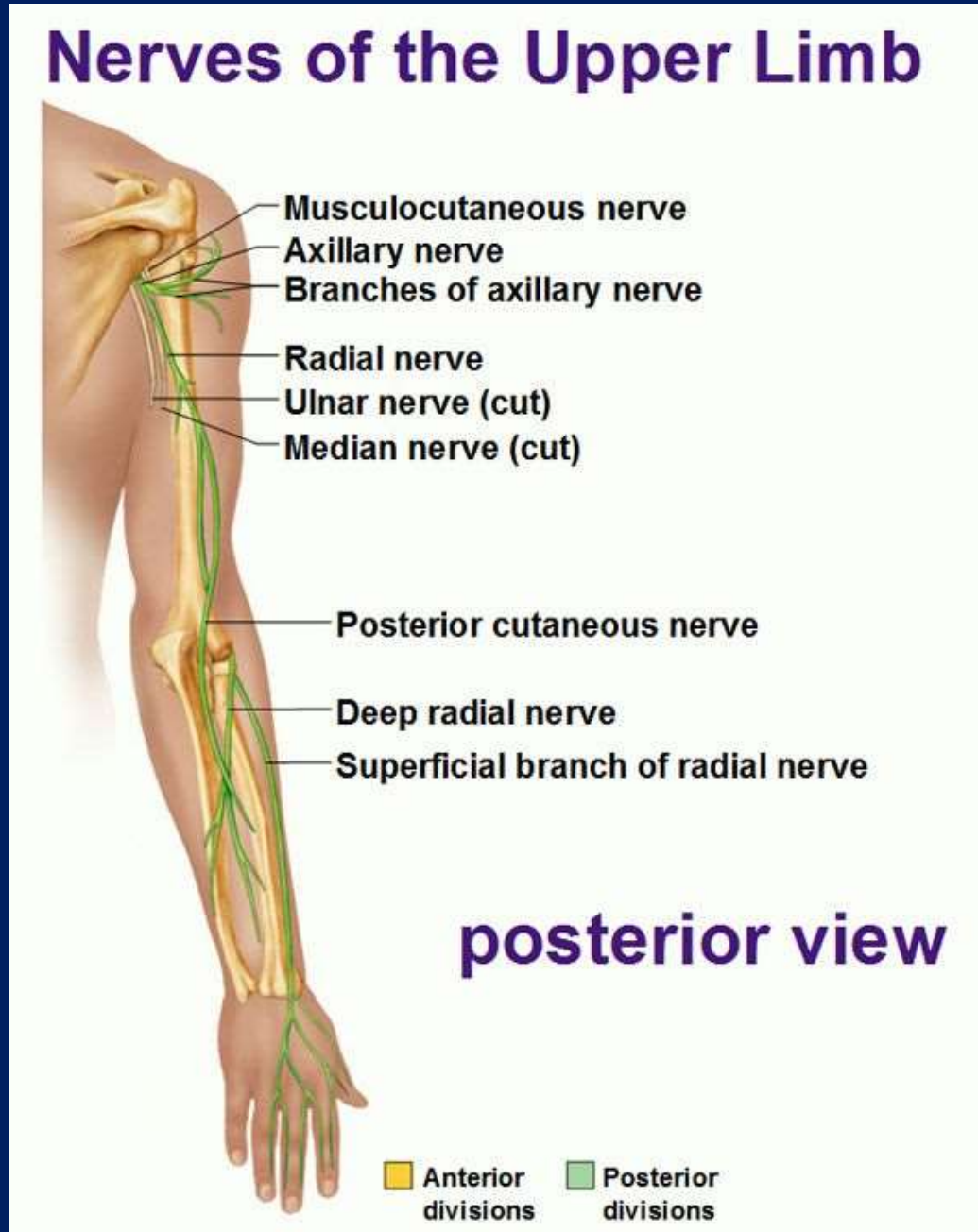
[Triceps not affected]

Dorsal forearm and hand numbness

- Axillary nerve palsy – tortuous route around surgical neck of humerus

Motor innervation anterior/middle deltoid muscle (weak abduction)

No sensory component



Take Home Rules for Injections

- Abduct arm to 60 degrees and inject midway between acromion and deltoid tuberosity
- Expose anatomy
- Anthropomorphic differences
    - Different length needles or penetration
    - Needle perpendicular to skin (90 degrees)
- Recognize complications
- **Population at risk: slender females**

“Classic” Neuralgic Amyotrophy Case Presentation

Patient awakens with new-onset severe shoulder/upper arm pain

Pain becomes unbearable in a several hours.

Paresis involving shoulder develops in hours to days

Typically involves the following combination of nerves -

Motor: Long thoracic, Suprascapular, Anterior interosseous

Sensory: Superficial radial, Lateral antebrachial cutaneous, Axillary (“soldier’s patch”)

Pt may not notice paresthesia because of severe intense pain.

Pain lasts 2–3 weeks and is recalcitrant to usual treatments.

Parsonage Turner Syndrome
Neuralgic Amyotrophy
Brachial Neuritis

Motor Nerves	Muscles
Long thoracic	Serratus anterior
Suprascapular	Supraspinatus, Infraspinatus
Anterior Interosseous	Pronator quadratus, Flexor pollicis longus, Flexor digitorum profundus (radial half)

Sensory Nerves	Distribution
Superficial radial	posterior forearm and hand
Lateral antebrachial cutaneous	radial forearm
Axillary	lateral shoulder

Clinical Presentation

van Eijk, et al., 2015

- Approximately 2/3 of cases are present in typical fashion

- Alternative presentations may involve a single nerve
  - Anterior interosseous
  - Median
  - Radial

- Pain, sensory (paresthesia), & motor (weakness) – different territories

- Lumbosacral plexus, phrenic nerve, recurrent laryngeal nerve

Neuralgic Amyotrophy

- Idiopathic Form – cause unknown
- Median age of onset mid-40's; wide age distribution
- Hereditary form 10%; median age of onset 25 yrs.
- Incidence of 2 – 4 /100 000
- Male/Female ratio $\geq$ 2/1
- Pathophysiologic mechanism unknown (multifactorial)

  Infections / Immune

  Mechanical factors (repetitive or strenuous motor tasks)

  Individual (genetic) susceptibility

Robinson & Fulcher, 2014; van Eijk et al., 2016

Clinical Course

- Mean duration of initial severe neuropathic pain ~4 weeks
  4.9% resolved within 48 hrs.
  22.7% resolved 1–7 days
- Mechano-sensitivity of affected nerves
- Musculoskeletal pain due to altered joint movement patterns
- Pain / deficits usually resolve, but may be present at 3 yrs.
- May recur in up to 25 %
- May be bilateral or affect contra-lateral side.

Robinson & Fulcher, 2014; Alcalay, et al., 2009

Etiology of Neuralgic Amyotrophy

- Half the cases – antecedent viral infections, immunization or intravenous drug exposure (streptokinase, heroin, interleukin-2, interferon-a2).
- Immune pathogenesis

  (+)anti-ganglioside antibodies in some patients

  (+) periph lymphocytes sensitized to brachial plexus antigens
- Immunizations: different vaccines, plus both botulinum formulations (botulinum toxin A and B), and steroid + lidocaine

Alcalay, et al., 2009

Table 2 The micro-organisms associated with Neuralgic Amyotrophy, based on Stek et al., 2011

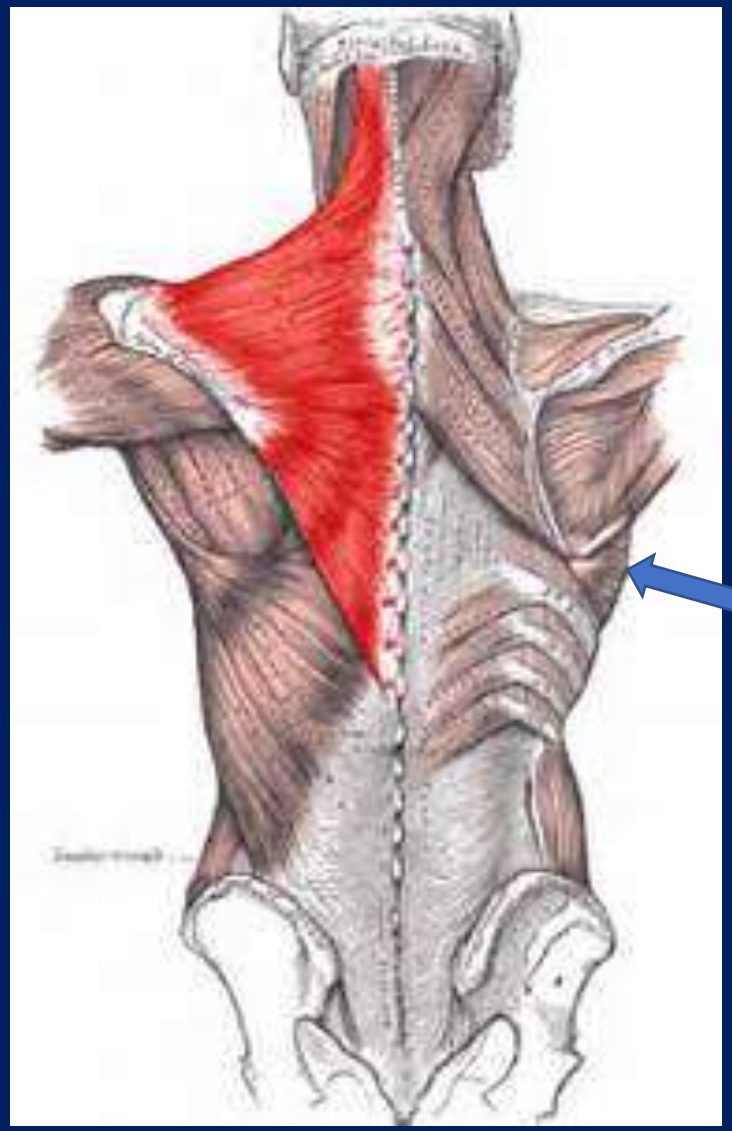
Viruses	Bacteria	Molds
Herpes simplex	Bartonella henselae	Aspergillus species
Epstein-Barr	Escherichia coli	
Cytomegalo	Borrelia burgdorferi	
Varicella zoster	Neisseria gonorrhea	
Parvo B19	Salmonella panama	
Human immunodefiency	Yersinia enterocolica	
Hepatitis B	Staphylococcus aureus	
Hepatitis E	Streptococcus group A	
Vaccinia	Brucella species	
Coxsackie B	Coxiella burnetti	
Dengue fever	Chlamydophila pneumoniae	
West Nile	Leptospira species	
	Mycoplasma pneumoniae	

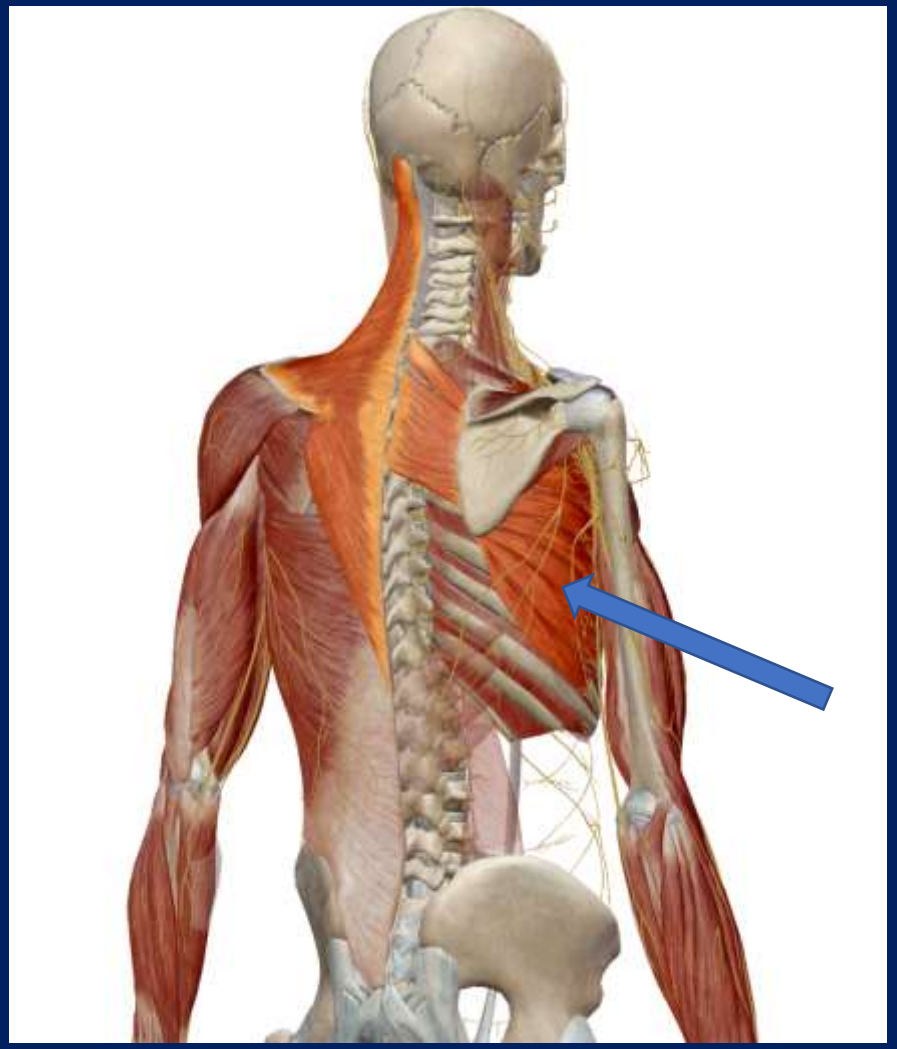
Immunizations associated w/ Neuralgic Amyotrophy

- Dtap
- Monovalent influenza vaccine
- Tetanus/diphtheria toxoid vaccine
- Papiloma virus
- hepatitis B
- Pneumococcal
- Botulinum toxin A and B
- Steroid + lidocaine

Scapular winging – weakness in **serratus anterior** (Long Thoracic Nerve)

Scapular Movement and Stability





Origin and Insertion of Serratus Anterior

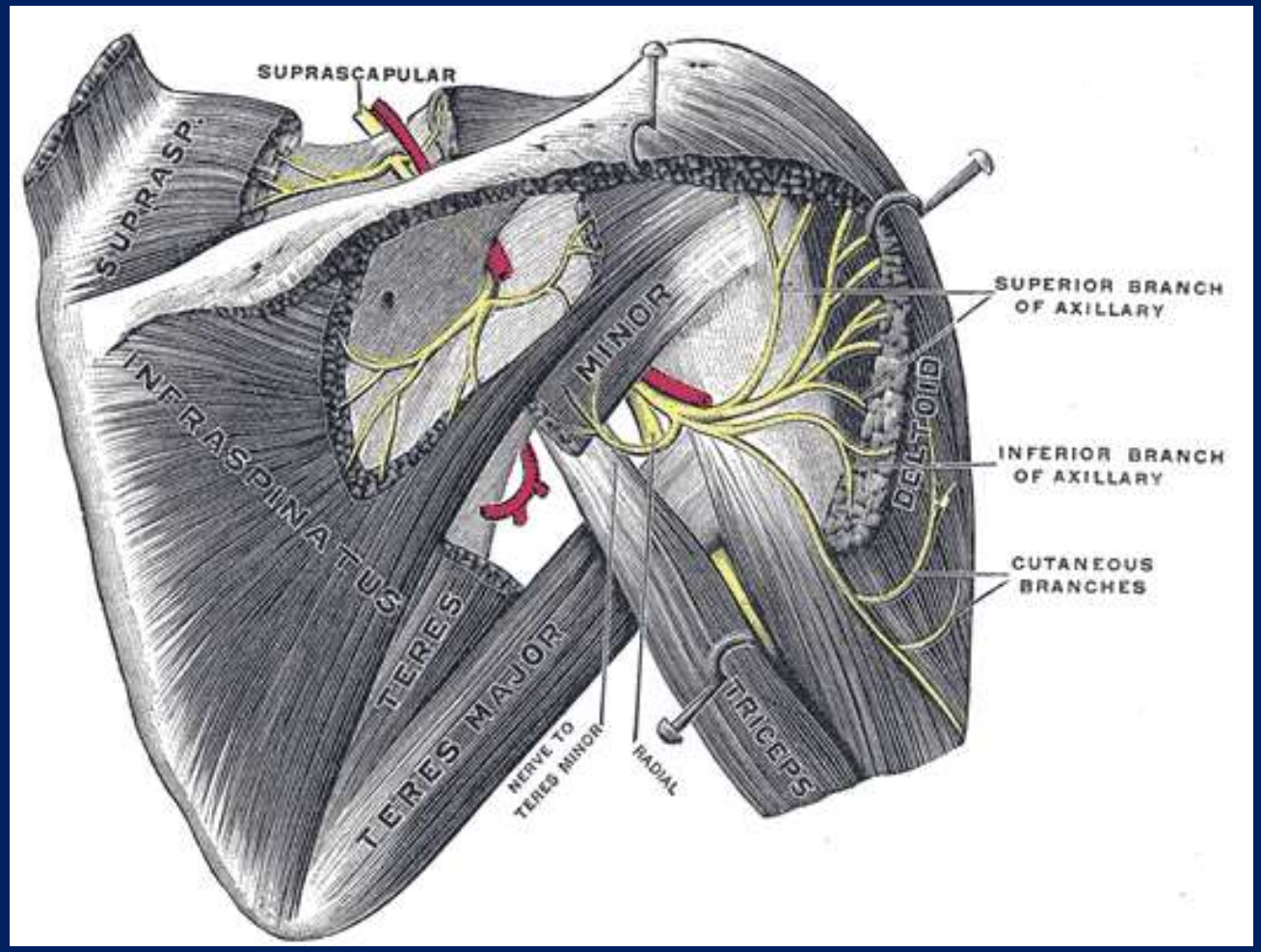
Suprascapular Nerve innervates Supraspinatus & Infraspinatus Muscles

Suprascapular Nerve – No peripheral sensory

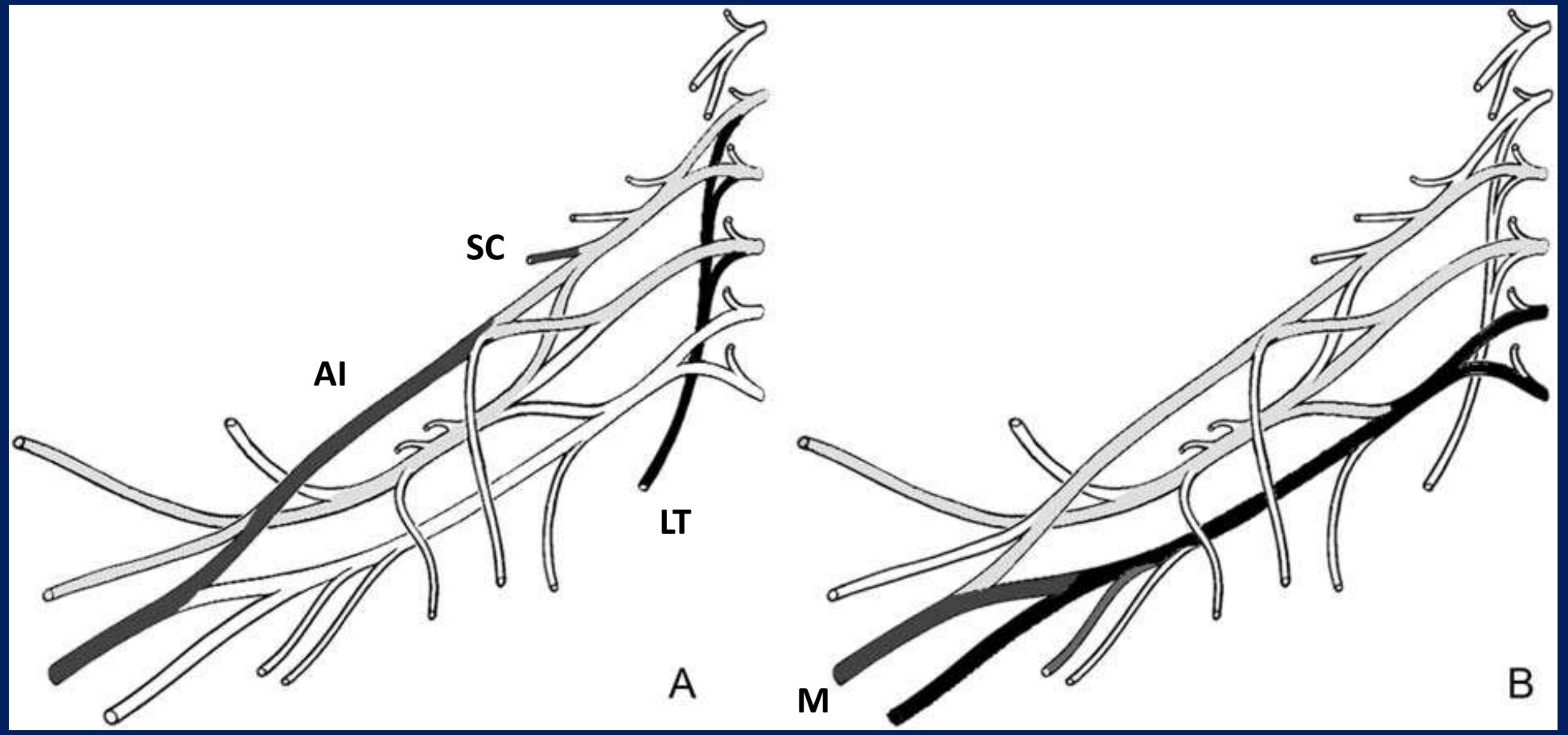
Muscles

Supraspinatus

Infraspinatus

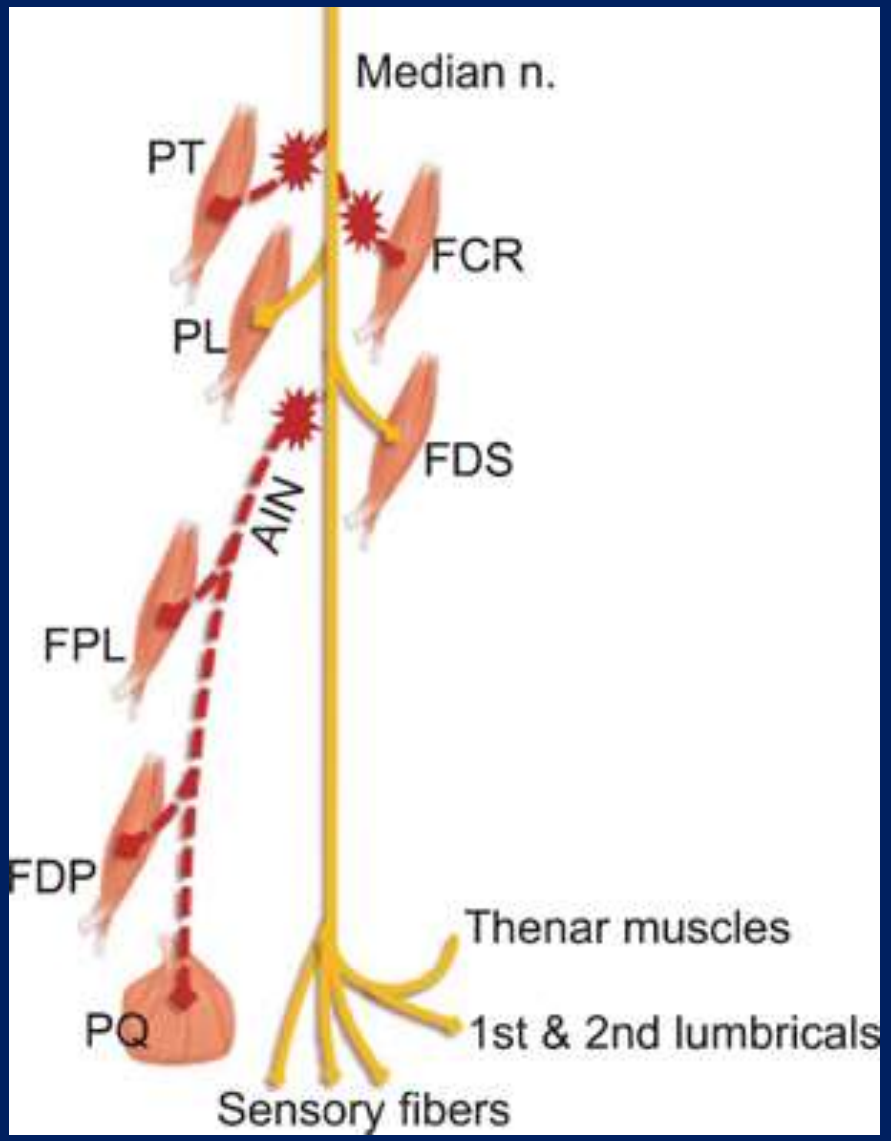


Brachial Plexus
(A) Typical presentation; (B) Less common

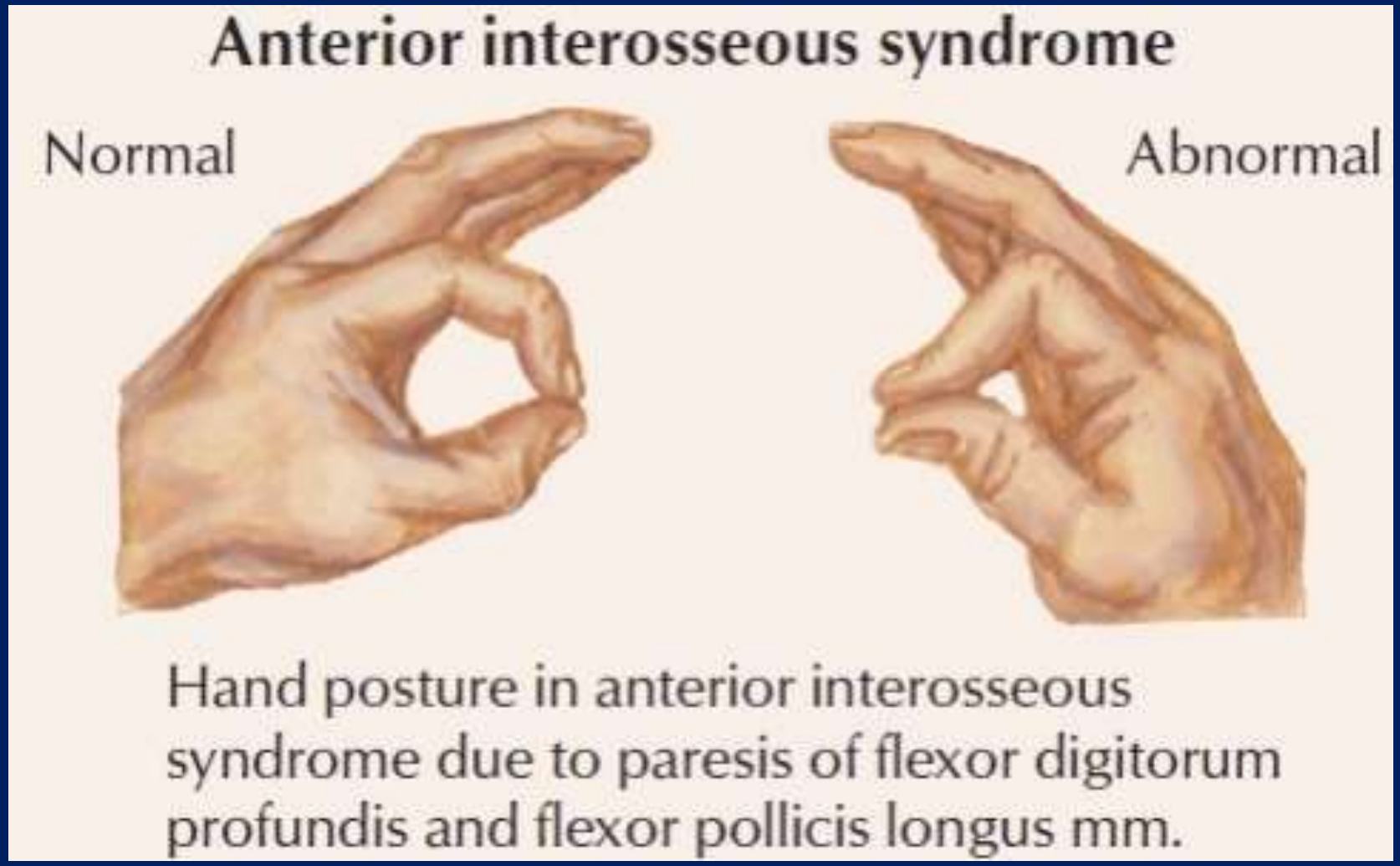


Anterior Interosseous Nerve – no peripheral sensory

<u>FPL, flexor pollicis longus</u>
<u>FDP, flexor digitorum profundus to 2nd & 3rd digits</u>
<u>PQ, pronator quadratus</u>
PT, pronator teres
FCR, flexor carpi radialis
PL, palmaris longus
FDS, flexor digitorum superficialis



Anterior Interosseous Nerve: “OK” Sign



Differential Diagnoses – Neurologic

- Cervical radiculopathy (C5)
- Fascioscapulohumeral syndrome
- Referred brachialgia(Primary) tumor
- Mononeuritis multiplex/vasculitis
- Multifocal motor neuropathy
- Asian tick-borne encephalitis
- Focal motor neuron disease
- Entrapment neuropathies
- Complex regional pain syndrome
- Lyme disease

Differential Diagnoses - Musculoskeletal

Van Alfen et al.

- Suprascapular nerve entrapments
- Rotator cuff tears
- Shoulder impingement syndrome
- Subacromial bursitis
- Calcific tendinopathy
- Adhesive capsulitis
- Osteoarthritis

Evaluation

IMAGING

- MRI shoulder and neck
- MRI Neurography

EMG/NCS – only to exclude other entities; frequently negative

LAB – usually negative

- Erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) – normal
- Autoimmune antibodies, like RF – negative
- Abnormal LFTs in the acute phase, due to antecedent HEV infection (an emerging infection in developed countries such as The Netherlands)
- Patients with specific risk profiles, serology for Borrelia burgdorferi, Bartonella henselae, or HIV is indicated

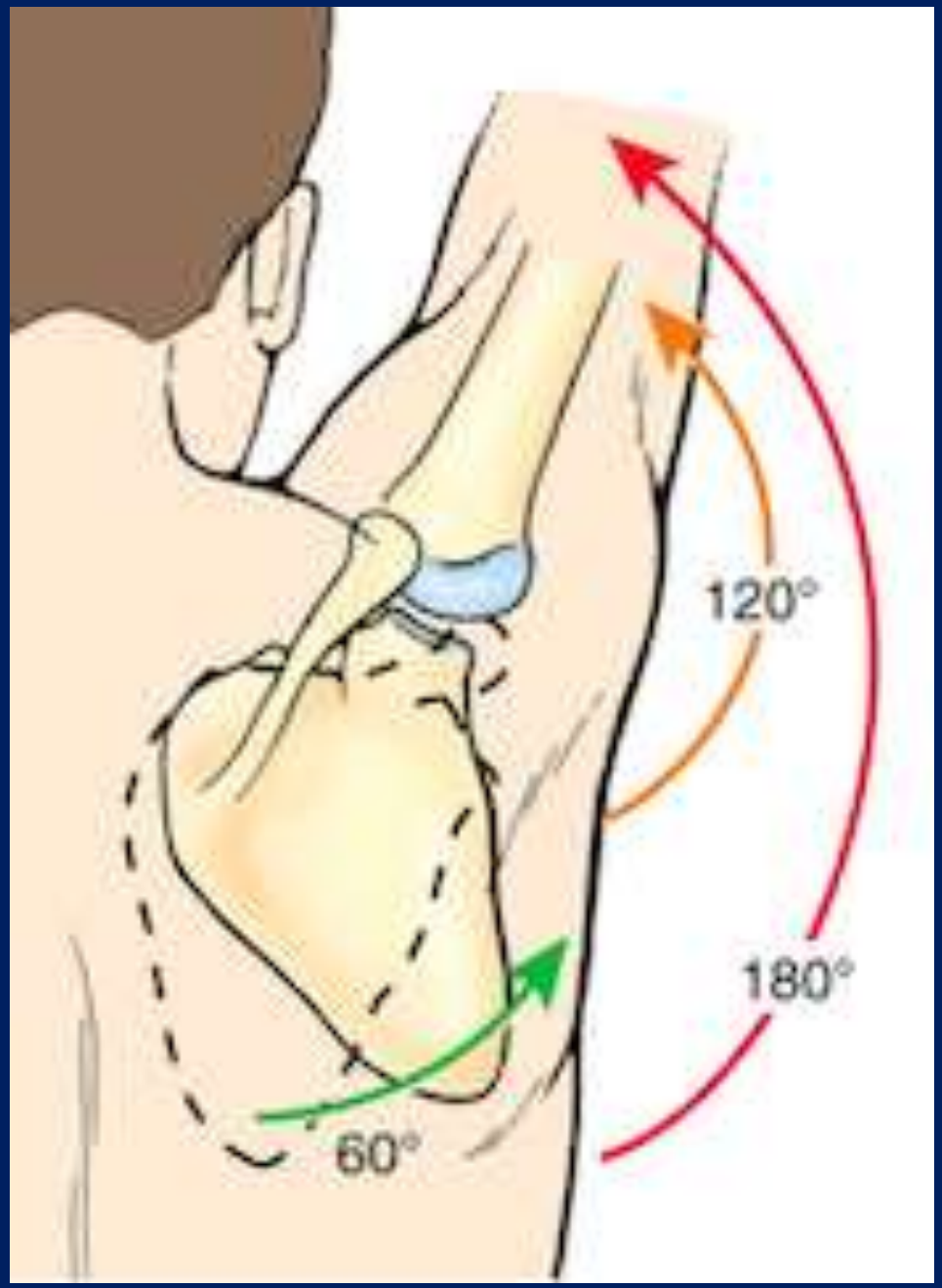
Van Eijk, et al., 2016

Complications of Neuralgia Amyotrophy

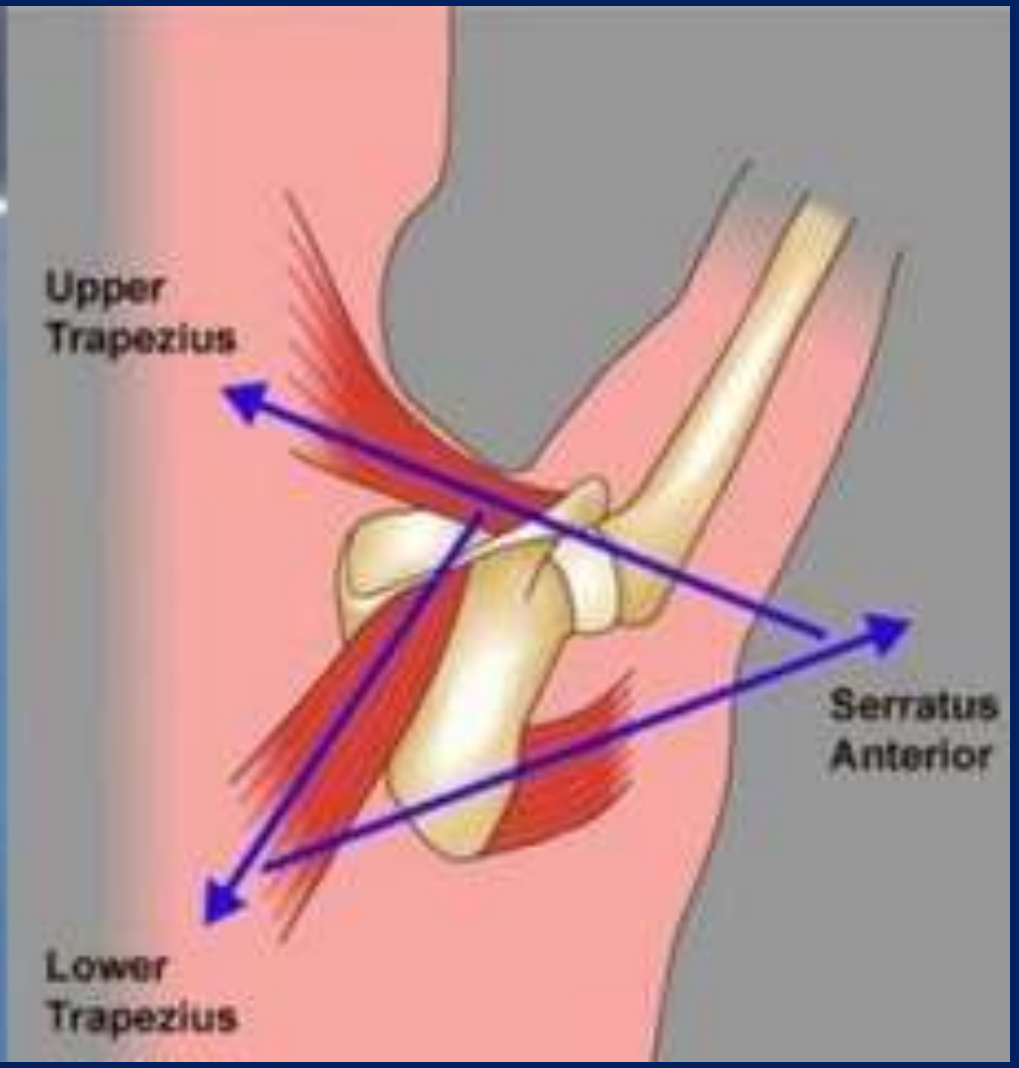
Affects mechanics of glenohumeral joint

- No medication
- No satisfactory brace
- No good surgical fix
- Strengthen in PT
- Activity modification

- 2:1 glenohumeral:scapular ROM
- Scapular ROM occurs above 90 degrees
- “Scapulohumeral rhythm”



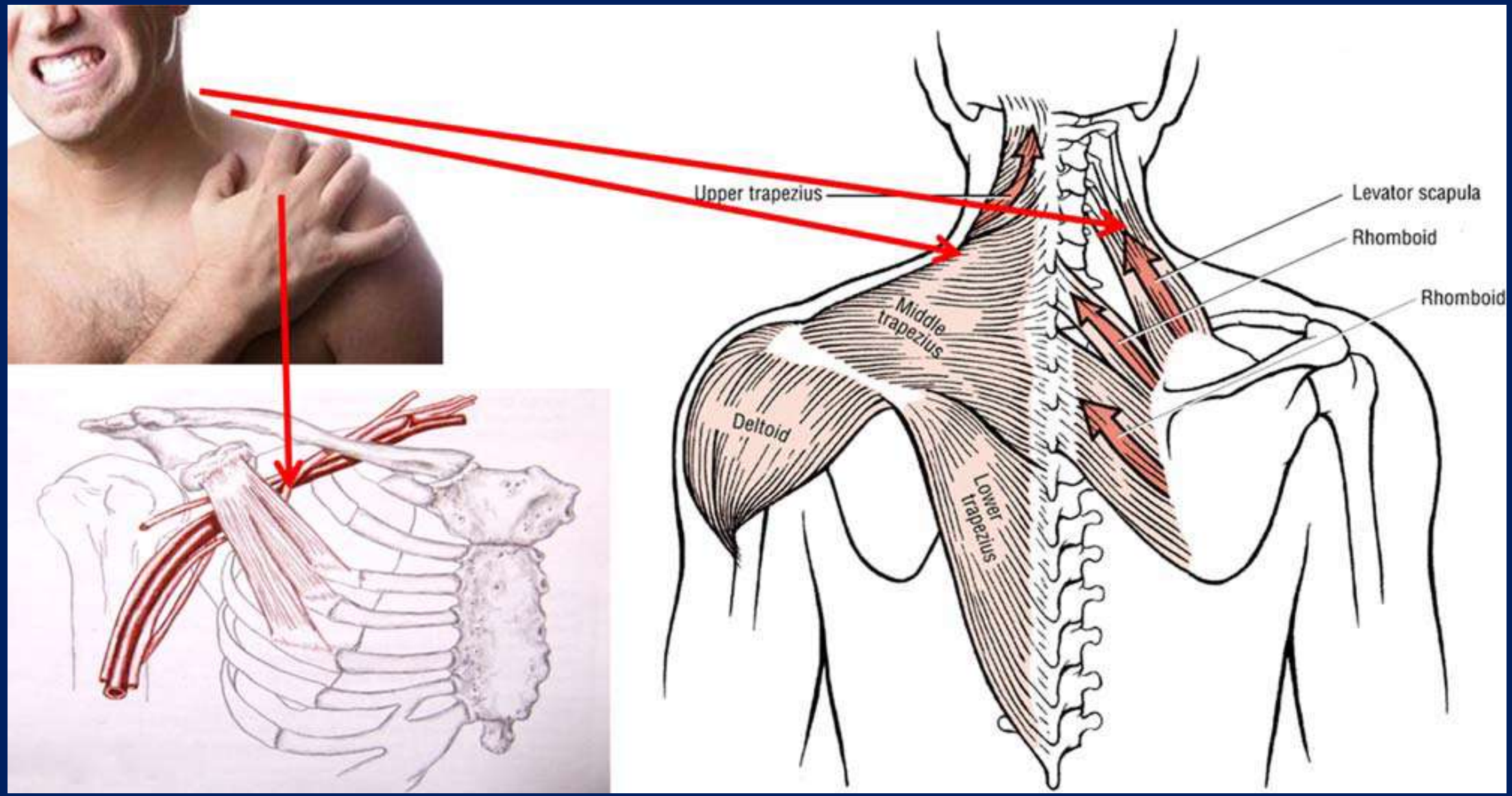
Role of Serratus Anterior in Scapulohumeral Rhythm



Aberrant Shoulder Mechanics secondary to Serratus Anterior weakness

Complications of Neuralgic Amyotrophy – weak SA

Aberrant mechanics - unbalanced forces from compensatory muscles cause pain



Questions?