SIRVA

Shoulder Injury Related to Vaccine Administration

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September 23, 2017
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.
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

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

**Variability** 1 to 11.2 cm

*Cook, 2011*
Do not inject below Anterior Apex of Axillary Line.

Injection site
Safe Injection Technique

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

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

Inject at midpoint between acromion and deltoid tuberosity

Cook, 2011; Cook, 2014
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

**Avascular musculotendinous insertion**

**Radial nerve**
Midway between acromion and deltoid tuberosity with arm abducted to 60° is a safe
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 \textit{(adipose)} and muscle-to-bone \textit{(muscle)} thickness
- 100 male and 100 female \textit{Indian} subjects; Average BMI 24.2 ± 4.9
  
  BMI correlates with shoulder adipose thickness in multiple studies.

\textbf{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 \( \geq 5 \) 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 Amyotrophia 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

<table>
<thead>
<tr>
<th>Motor Nerves</th>
<th>Muscles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long thoracic</td>
<td>Serratus anterior</td>
</tr>
<tr>
<td>Suprascapular</td>
<td>Supraspinatus, Infraspinatus</td>
</tr>
<tr>
<td>Anterior Interosseous</td>
<td>Pronator quadratus, Flexor pollicis longus, Flexor digitorum profundus (radial half)</td>
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</table>

<table>
<thead>
<tr>
<th>Sensory Nerves</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superficial radial</td>
<td>posterior forearm and hand</td>
</tr>
<tr>
<td>Lateral antebrachial cutaneous</td>
<td>radial forearm</td>
</tr>
<tr>
<td>Axillary</td>
<td>lateral shoulder</td>
</tr>
</tbody>
</table>
Clinical Presentation

• 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

van Eijk, et al., 2015
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 > 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

<table>
<thead>
<tr>
<th>Viruses</th>
<th>Bacteria</th>
<th>Molds</th>
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</thead>
<tbody>
<tr>
<td>Herpes simplex</td>
<td>Bartonella henselae</td>
<td>Aspergillus species</td>
</tr>
<tr>
<td>Epstein-Barr</td>
<td>Bartonella henselae</td>
<td></td>
</tr>
<tr>
<td>Cytomegalovirus</td>
<td>Escherichia coli</td>
<td></td>
</tr>
<tr>
<td>Varicella zoster</td>
<td>Borrelia burgdorferi</td>
<td></td>
</tr>
<tr>
<td>Parvo B19</td>
<td>Neisseria gonorrhoea</td>
<td></td>
</tr>
<tr>
<td>Human immunodeficiency</td>
<td>Salmonella panama</td>
<td></td>
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<tr>
<td>Hepatitis B</td>
<td>Yersinia enterocolica</td>
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<tr>
<td>Hepatitis E</td>
<td>Staphylococcus aureus</td>
<td></td>
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<tr>
<td>Vaccinia</td>
<td>Streptococcus group A</td>
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<tr>
<td>Coxsackie B</td>
<td>Brucella species</td>
<td></td>
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<tr>
<td>Dengue fever</td>
<td>Coxiella burnetti</td>
<td></td>
</tr>
<tr>
<td>West Nile</td>
<td>Chlamydophila pneumoniae</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Leptospira species</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mycoplasma pneumoniae</td>
<td></td>
</tr>
</tbody>
</table>
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

FPL, *flexor pollicis longus*
FDP, *flexor digitorum profundus* to 2nd & 3rd digits
PQ, *pronator quadratus*
PT, *pronator teres*
FCR, *flexor carpi radialis*
PL, *palmaris longus*
FDS, *flexor digitorum superficialis*
Anterior Interosseous Nerve: “OK” Sign

Hand posture in anterior interosseous syndrome due to paresis of flexor digitorum profundis and flexor pollicis longus mm.
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

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

Van Alfen et al.
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?