IS IT NECK PAIN OR IS IT SHOULDER PAIN?
NERVE ENTRAPMENT SYNDROMES AROUND THE NECK THAT MIMIC SHOULDER PAIN

PHILLIP STEELE, MD, RMSK, CAQ
SPORTSMEDICINE
PERFORMANCE INJURY CARE & SPORTS MEDICINE

DISCLOSURE

- I have nothing to declare.
- I no longer have the medical school nightmare about the brachial plexus.

OBJECTIVES

- Looking at shoulder and neck pain with an expanded differential list.
- Realize that nerve entrapments are commonly overlooked around the shoulder.
- Brachial plexus variations are common.
- Cervical plexus variations are common.
NERVE INJURY PATHOPHYSIOLOGY

Nerves traversing through the neck-shoulder region have many areas of restriction secondary to changing angles to help accommodate for multidirectional shoulder motion. These angles cause traction to the nerve during activities such as throwing and overhead work.

- Compression mechanism secondary to fixed position through the shoulder, backpack straps, or injury to the shoulder.
- Stretching mechanism secondary to acute angles of fixation, traversing through muscles, body positioning, trauma, and abrupt stretch injury.
- Trauma mechanism secondary to fracture, dislocation, fracture or whiplash.

THE PROBLEM

- Neuropraxia pain is difficult to identify.
- Traditional testing with EMG and MRI is useful for axonotmesis & neurotmesis.
- Weakness and atrophy are late findings.

SENSITIVITY & SPECIFICITY?

- MRI has good sensitivity (69%) of late-stage disease.
- MRI specificity for small peripheral nerves is only 20-50%.
- EMG has poor sensitivity for small peripheral nerve entrapments (<50%).
- EMG/NCCT generally poor at identifying neuropraxia injury.

- A good neuro exam is often more sensitive & specific than traditional testing.
MSK ULTRASOUND FOR PERIPHERAL NERVE ENTRAPMENT

- Diagnostic ultrasound has a higher sensitivity & specificity than conventional testing.
- Requires a skilled sonographer.
- Can be used for both diagnostic and therapeutic.
- Functional and live scanning can identify the entrapment.
- Same inherent problems of MRI and EMG if large sized individual.

ESSENTIAL ANATOMY FOR SHOULDER PAIN

- C5 & C6
- Dorsal scapular nerve
- Long thoracic nerve
- Suprascapular nerve
- Spinal Accessory nerve
- Suprascavicular nerve
- Axillary nerve

WHAT TO DO WHEN NOTHING MAKES SENSE?

- Scapular movement exam is critical
- Muscle testing with neck sidebend to contra-lateral side.
- Sensory exam with neck sidebending?
- Stretching or compression exam of scalene muscles.
- Weakness overhead, loss of throwing or hitting velocity.
BRACHIAL PLEXUS SONOANATOMY

- Sonoanatomy of the brachial plexus has made tremendous advances with the availability of faster processing speed and high resolution probes.
- Little attention has been paid to the variations of normal anatomy described in cadaver studies.

The relationship between these known anatomical variation and pathology is in its infancy.

NORMAL ROOT SIZE

- No study correlates root size.
- Normal is less than 12mm circumferential?
- C6 is generally around 10mm?
- Greater than 14mm is enlarged?
- Comparison with other side.
- Important to scan before and after surgery?
- Parsnage Turner 26mm.
- C5 is commonly smaller than C6 by 1-2 mm as DSN branches early.

VARIATIONS OF THE BRACHIAL PLEXUS

- Brachial plexus variations are normal.
- 1/2 of cadaver studies show variations of the brachial plexus.
- Accessory scalene is commonly found 25%?
- Pre fixed CA is very common (25%).
- C3 piercing through the anterior scalene (13%).
- C5 traversing around anterior scalene (3%).
BRACHIAL PLEXUS VARIATIONS

Kerr catalogued 29 forms of the brachial plexus among some 175 cadaver specimens dissected between 1895 and 1910.

In the early part of the last century, one author described a total of 38 variations of the plexus.

Up to 53.5% of plexuses in cadaver studies possess significant anatomic variation from the “classic” description.

FREQUENCY IN THE PATIENT COMPLAINING OF NECK AND SHOULDER PAIN?

- No study looks at the frequency of these variations in the injured patient.
- No study looks at anatomic brachial variations before cervical fusion.
- C5-6 degenerative disc disease is most common level...most common brachial plexus variation is C5.
- No study looks at cervical plexus variations and relationship to shoulder, neck and headaches.

In one study they dissected the necks of 65 human cadavers, traced the paths of the brachial plexus nerves, and documented the relationships between the nerves, arteries, and muscles of the neck. 45% of the time they found previously undescribed variations. In one part of the brachial plexus there is a normal variation in which part of the brachial plexus travels through the muscle belly of the anterior scalene. These variations were described in patients with neurogenic symptoms, including severe neck pain, subclavian artery symptoms, and focal muscle weakness. The study authors noted a normal variant in which the subclavian artery travels between the scalene muscles, resulting in irritation of the roots of the brachial plexus. This anatomical variation, therefore, may be one cause of the large number of currently undiagnosed TOS cases.

BRACHIAL PLEXUS VARIATIONS OF PATIENTS WITH NECK AND SHOULDER PAIN

- Although many variations exist we will focus on patients presenting with shoulder and neck pain.
- Patient typically have pain greater than 1-11 year, MRI of shoulder and neck before referral.
- Most patients have a history of stretch or compressive injury.
- History of lateral or posterior shoulder pain, burning, vague or radicular pain, some with weakness.
- Most have had several procedures including cervical fusion, rotator cuff surgery, thoracic outlet surgery, pain management.

C6 flips over C5
C5 PIERCING ANTERIOR SCALENE (13%)

- Most common C5 variation can cause compression & swelling of the root.
- History of lifting and carrying, construction worker.

C5 AROUND ANTERIOR SCALENE (3%)

- C5 can traverse anterior and around the anterior scalene causing compression and swelling of the root.
- Presenting with lateral shoulder pain, scapular pain, and weakness with neck rotation away.

TAUGHT FIBROUS BAND OF ANTERIOR SCALENE

- Increased shoulder pain with rotation of neck away from ipsilateral shoulder.
- Neck movement aggravates shoulder pain.
C5 COMPRESSION FROM A NARROWED MUSCULAR AS/MS INTERVAL

• Overdevelopment of the anterior scalene in the setting of the C5 root piercing through the AS muscle can create a compressive C5 radiculopathy.

C5 SHARPLY LOOPS AROUND ANTERIOR SCALENE

• Whiplash injury now with chronic pain.
• Burning lateral shoulder pain without RTC tear or impingement findings.

ANTERIOR TUBERCLE OF C6 COMPRESSION OF C5

• Narrowed AS/MS interval and C5 travels around AS.
• Both scapular dysfunction and radiculopathy to wrist.
C5 & C6 PIERCE ANTERIOR SCALENE
- C/O lateral and posterior shoulder pain and radiculopathy below the elbow.
- Subtle weakness to shoulder and bicep.

ACCESSORY SCALENE
- Muscular layer divides C5-C6.
- Can divide C5-C6 from C7 & C8.

ACCESSORY SCALENE
- Can cause tethering of the cervical roots and increases risk for stretching injury with overhead sports.
TREATMENT?

- Avoid deep tissue work, over-stretching, dry needling.
- Stop the digging!
- Less is more!
- Ultrasound guided injections/ hydrodissection.
- Diagnosis is half the battle.

CERVICAL PLEXUS?
SHOULDER PAIN

- Spinal accessory nerve
- Supraclavicular nerve (3)
- Lessor occipital nerve (2)
- Greater auricular nerve (5)
- Transverse cervical nerve (1)

CERVICAL PLEXUS ANATOMY

- The supraclavicular nv can be identified at the C4 level.
- Spinal accessory is a cranial nv that typically appears at the level of C3-4 under the SCM.
- LON, GAN and TCN can all cause neck pain and headaches.
- Many accessory branches exist between GON, LON & GAN.
- Injections of these nerves can create radicular pain into the shoulder.
IMPORTANT CERVICAL PLEXUS VARIATIONS

- After appearing from underneath the SCM, the motor branch of the SAN pierces into the SCM leaving several motor branches before exiting and heading towards the trapezius.
- Unknown frequency of variation.
- Appears to tether SAN within SCM increasing risk for traction injury.

SPINAL ACCESSORY NERVE

- Not a true peripheral nerve (CN XI).
- Innervation of the SCM & Trapezius after exiting the base of the skull at jugular foramen.
- Picks up contributions from C2-4.
- Injury from direct trauma, iatrogenically by surgical procedures.
- Traction injury after fall to lateral shoulder and neck.

SPINAL ACCESSORY PE FINDINGS

- May cause weakness to SCM & Trapezius.
- Causes mild to severe pain.
- Scapular winging (inferior tip) is seen with abduction not with forward flexion.
- Internal rotation of shoulder at rest.
- Abnormal shrug test, weakness to prolonged forward flexion, difficulty with full abduction.
- Patients complain of a heavy shoulder.
- Normal contour of the neck and shoulder is lost with prominent AC joint.
SUSPECT SAN INJURY

- Loss of motion similar to frozen shoulder, frozen abduction.
- Persistent myofascial trigger point over the nerve. Many therapies, massage, acupuncture, dry needling, "knots".
- Impingement syndrome that won't go away.
- Snapping shoulder syndrome
- Failed shoulder rehab with minimal MRI findings.
- Crepitation of the superior scapula.

TREATMENT SAN ENTRAPMENT

- Avoid massage, stretching, digging, dry needling.
- Try talking with PT
- If no significant improvement: hydro-dissection of entrapment.

SCAPULAR MOTION TESTING

- SAN entrapment causes winging with abduction.
- Long Thoracic nn entrapment causes winging with forward flexion. Increase scapula crepitation.
- Dorsal scapular nn entrapment causes lateralization of the inferior angle of the scapula that worsens with neck extension. Wings away from the thorax.
**SHOULDER WEAKNESS PATTERNS**

- Axillary nerve entrapment causes weakness to extension.
- Dorsal scapular nerve entrapment causes weakness to rowing motion or fly’s type motion.
- Suprascapular nerve entrapment causes weakness to external rotation and abduction from 0-30 degrees.
- Spinal accessory nerve weakness causes weakness to shrug and shoulder elevation.

**SUPRACLAVICULAR NERVE ENTRAPMENT**

- Arises from third and fourth cervical nerve.
- Emerges beneath the posterior border of the SCM.
- Three branches: Anterior, middle and posterior.
- Rarely, a branch pierces the clavicle through a osseous tunnel causing entrapment (1%).
- Occurs after fracture, surgical fixation, healing callus, neuroma after transection, variations of anatomy involving fibrous bands, muscle & tendons.
- Arthroscopy portal incisions.
- Can be injured in traction or stretch injury.

**HYPERESTHESIA AFTER CLAVICLE FRACTURE**

- Case reports of tented clavicle fractures impinging the SCN.
- Symptoms of nerve entrapment of the SCN may extend beyond the anatomical zone & include the proximal deltoid & posterior-lateral scapula.
- 49% have additional intermediate branches.
- The precise location of each branch is highly variable.
- No clinically relevant predictable safe zone.
SUPRACLAVICULAR NERVE ENTRAPMENT

- Pain out of proportion to shoulder injury consider SCN entrapment.
- EMG and MRI typically not useful.
- Skilled sonographer can follow branches down to entrapment or neuroma site.
- Consider just injecting portal incision site with lidocaine if skilled MSKUS sonographer unavailable.
- Ultrasound guided hydrodissection for diagnosis & treatment.
- Consider surgical decompression.

SUPRACLAVICULAR - CERVICAL PLEXUS TRACTION INJURY

- Hyperesthesia pain to the shoulder & neck.
- May include posterior ear (GAN), jaw (TCN) & occipital headaches (LON).
- Stretch test of SCM increases pain.
- Strength testing of SCM increases pain.
- Seat belt injury to neck causing hyperesthesia.

HEADACHE & NECK PAIN

- Cervical plexus stretch injury that includes jaw ache, posterior ear pain and or occipital head ache pattern consider cervical plexus injury.
- Trapezius is tight with multiple trigger points.
- Headache that starts at Erb’s point.
DORSAL SCAPULAR NERVE ENTRAPMENT SYNDROME

- Interscapular pain, shoulder and arm pain.
- Sharp, stabbing, burning, knife-like, medial scapular, lateral shoulder pain & forearm.
- Neck and back pain with a sense of traction.
- Itching sensation.
- Scapular winging often not noticed.
- Can be injured during interscalene injections for anesthesia for shoulder surgery.
- Long thoracic nerve is often injured in conjunction.

DORSAL SCAPULAR NERVE INJURY ETIOLOGY

- First branch of C5, can share a common root with long thoracic nerve, enter middle scalene and travels posterior towards trapezius.
- Trauma to the scalene muscles caused by stretching during cervical hyper-extension and hyper-flexion injury.
- Entrapment in the middle scalene muscle.
- Seen in the overhead worker such as painter or electricians.
- Can be injured during shoulder dislocation or traction injury to the shoulder.

DORSAL SCAPULAR NERVE INJURY

- Pain along the medial border of the scapula.
- Radiation to the lateral surface of the arm and forearm.
- Complaints of shoulder pain and dysfunction.
- Difficulty bringing scapula together.
- Thoracic outlet like syndrome
- Notable difference with dumbbell lifting secondary to fatigue and weakness.
DSN PHYSICAL EXAM FINDINGS

- If chronic, there may be atrophy of the rhomboids and levator scapulae.
- Winging of the vertebral border of the scapula away from the thorax with forward flexion.
- With abduction of the shoulder, the inferior angle of the scapula on the affected side will travel further laterally towards the mid axillary line.
- Asymmetry of medial scapula border at rest. Symptomatic side is usually 1cm lateral. Head forward posture, lateral flexion and rotation to relax the involved scalene.
- If no weakness, rotate head and neck to increase tension of the middle scalene and retest.

DSN TREATMENT OPTIONS

- May share a common trunk with the long thoracic trunk and have a mixed picture.
- It pierces the middle scalene muscle and travels between the posterior scalene muscle and serratus posterior & levator scapulae and can be blocked at this level.
- Injury during shoulder dislocation and hypertrophy of middle scalene. (Rest)
- Conservative treatment initially with stretching of the scalene muscles, rhomboid strengthening and myofascial release with PT.
- Entrapment may be middle scalene, deep to the levator scapula over rib & medial border of the scapula.
- Hydrodissection versus surgical decompress if chronic.

LONG THORACIC NERVE INJURY

- Pure motor nerve.
- Traverses distally & laterally below the clavicle within the substance of the middle scalene.
- Repetitive microtrauma from stretching the nerve while the arm is in an overhead position and neck is turned or tilted away.
- Can be stretched over the rough prominence of the second rib.
- Direct trauma.
- Neuralgic amyotrophy.
- Subcoracoid bursa compression.
LONG THORACIC NERVE

• Occasional C4 branch may unite with the C5 branch.
• C5-6 portion LTN traverses down and through the middle scalene while the C7 portion passes between the anterior & middle scalene.
• They unite distal to the scalene muscle to form the LTN.

LONG THORACIC NERVE INJURY SYMPTOMS

Secondary pain and spasm result from muscle imbalances and tendinitis around the shoulder joint caused by muscular activity that compensates for impaired shoulder stability. Winging also leads to adhesive capsulitis, subacromial impingement, and brachial plexus radiculitis.

Injury to the long thoracic nerve causing paralysis or weakness of the serratus anterior muscle can be disabling. Patients with serratus palsy may present with pain, weakness, limitation of shoulder elevation, and scapular winging with medial translation of the scapula, rotation of the inferior angle toward the midline, and prominence of the vertebral border. Long thoracic nerve dysfunction may result from trauma or may occur without injury. Fortunately, most patients experience a return of serratus anterior function with conservative treatment, but recovery may take as many as 2 years.

LONG THORACIC NERVE INJURY IN SPORT?

• Throwing sports with head turned away.
• Scheduling or serving volleyball or tennis.
• Ballet and yoga stretches.
• Missed shot or follow-through.
• Missed punch in boxing.
• Prolonged repetitive motion such as swimming, rifl shoot, archery, gymnastics, backpacking.
• Weightlifter (behind the neck) or bench press.
• Direct trauma with a blow to the thorax.
LONG THORACIC NERVE PAIN SYMPTOMS

- Pain in the shoulder and periscapular region that can radiate down the arm and up into the neck.
- Pain is worse with overhead activity.
- Muscle pain is frequently posterior secondary to rhomboid and levator scapula spasm due to overactivity/compensation for weakened serratus anterior.
- Painful popping and click of the scapula with shoulder motion.
- May have shoulder weakness and loss of throwing power.

LTN PHYSICAL EXAM FINDING

- Winging of the inferior border of scapula with forward flexion or wall push-up.
- At rest, elevation and retraction of the scapula such that the inferior pole appears closer to midline and slightly elevated.
- Symptoms may worsen with overhead activity and tilting head away from elevated arm.
- Painful middle scalene stretch?
- Increased wing with stretching the neck away from affected winging?

LONG THORACIC NERVE EVALUATION

- Can be challenging to visualize with MSK ultrasound.
- Can be seen in the supra & infraclavicular regions.
- Can be seen in the fascial plane of medial and posterior scalene muscles.
- Susceptible to traction injury between two points of relative fixation between middle scalene base and superior aspect of the serratus anterior impulse.
- Can be injured secondary to stretching over a rough prominence on the second rib.
WHAT HAPPENS DURING SHOULDER MOVEMENT?

In a situation of LTN compression, weakness of the serratus anterior means that full upward rotation of the scapula does not occur during abduction.

Consequently, range of motion in abduction is diminished. However, when the scapula does not move in full upward rotation, the lateral edge of the humeral head is more likely to contact the underside of the acromion process during abduction, leading to shoulder impingement and potential damage to soft tissues in the subacromial region, including the bursa, supraspinatus, or joint capsule.

RECOVERY LONG THORACIC NERVE

- Non-surgical, activity modification to avoid additional stretch to the nerve.
- Avoid hands behind head.
- Therapeutic exercise, gentle stretching program.
- Middle scalene hydrodissection.
- Infraclavicular entrapment with pec hypertrophy?
- Avoid fixed, retracted position of scapula on chest wall.
- Up to two years for recovery.
- Less may be more.

SUPRASCAPULAR NERVE ENTRAPMENT

- Appears to be the most commonly injured peripheral branch of the brachial plexus in sports.
- Typical presentation is painless weakness of the external rotators.
- Vague shoulder pain to the lateral shoulder as presenting complaint (15% deltoid patch).
- Posterolateral, dull, burning, deep or diffuse. Worse with overhead.
- Cutaneous sensory branches from GHJ, ACJ, CCL, CHL.
SUPRASCAPULAR NERVE INJURY

- Paralabral cyst thought to be the most common cause.
- 28% of full thickness RTC tears are associated with nerve entrapment.
- Osteoarthritis.
- Calcification of the superior transverse scapular ligament (STSL).
- Iatrogenically RTC repair, distal clavicle resection & arthroscopic shoulder stabilization.
- Consider in the setting of shoulder pain with minimal MRI findings.

SUPRASCAPULAR NERVE INJURY IN SPORTS

- Frequency of the disorder is increasing as it appears to be common in volleyball, baseball and other overhead or throwing sports.
- Volleyball float serve, pitchers, racquet sports.
- One study up to 45% of shoulder pain in athletes. EMG testing 33% of serving side volleyball.
- Decrease throwing velocity and or hitting power.
- Pain with over head work.
- Backpack shoulder straps.

SUPRASCAPULAR NOTCH IMPINGEMENT

- The nerve courses through the suprascapular notch which is bridged by a thick transverse scapular ligament (Narrowed, brid or calcified).
- In the supraspinatus fossa, two motor branches and a sensory branches to the posterior capsule of the GH and AC joints.
- Entrapment (stretch) occurs as the nerve is relatively fixed at the suprascapular notch.
- Maximal stretch of the nerve with cross-body adduction or protracted forward flexion (fencing, throwing & racket sports).
- Causes weakness of both abduction and external rotation.
**SPINOGLENOID NOTCH ENTRAPMENT**

- More commonly seen in athletes whose sports require rapid forceful external rotation movements.
- Cocking motion for the smash!
- Rapid motion of the infraspinatus muscle pulls the suprascapular nerve against the base of the scapular spine.
- Stretching of the infraspinatus secondary to sharp bend after the spinoglenoid notch.
- Can present as painless wasting of the infraspinatus.
- External rotation weakness only.

**PROXIMAL SUPRASCAPULAR NERVE INVOLVEMENT**

- Suprascapular nerve can be entrapped before the suprascapular notch as the first motor branch to the supraspinatus branches within 1 cm of the suprascapular ligament.
- Fixed position of the SSN secondary to periosteum attachment.
- Repetitive stretch and throw may cause proximal swelling.
- Omohyoid test.

**THERAPY FOR SUPRASCAPULAR ENTRAPMENT**

- NSAID's, rest, activity modifications & biomechanics, 6-12 months.
- Rehab focus on RTC, deltoid, scapular stabilization posterior capsule stretching.
- US guided neurohydrolysis, aspiration.
- Cortisone ?
- Address structural lesion as treatment depends on etiology.
- Traumatic 65%, inflammatory 28%, cyst 26%.
- Surgical nerve decompression.
Axillary Nerve Entrapment

- Acute shoulder dislocation (20%)
- Direct blow to anterior-lateral deltoid.
- Overhead workers.
- May occur with severe motor findings without sensory findings.
- Acute axillary neuropathy (backpacking)
- Posterior portal for arthroscopy (1%-8%).
- Infraspinatus tendon injection.
- Parsonage-Turner Syndrome.

Axillary Nerve Injury

- Injury associated with the hyper-laxity of the shoulder (MTBI)
- Weakness and fatigue with overhead activity with lifting.
- Subtle numbness to lateral shoulder & weakness to deltoid.
- May present as "frozen shoulder".
- Weakness with abduction beyond 30 degrees.
- Dominant arm volleyball from repeated stretching of the nerve.

Axillary Nerve

- Involves compression of the axillary nerve and posterior circumflex artery.
- Typical presentation is vague & nonspecific.
- Pain is usually dull, burning or deep ache.
- Worse with overhead activity.
- Deltoid and teres minor weakness.
- Dead arm, posterior lateral pain in a non dermatomal pattern.
- Point tenderness Q/S, pain with abduction and external rotation.
Quadrilateral Space Syndrome Evaluation

- MRI is useful if tumor or space-occupying lesion. Arteriogram may be helpful.
- EMG’s typically negative as this is an intermittent compression with overhead work.
- US is helpful for overhead evaluation as Doppler US can be used to evaluate for neurovascular compromise/compression during abduction or overhead positioning.

 AXILLARY NERVE ENTRAPMENT TREATMENT

- Limit overhead work.
- Stretching program.
- PT/OT.
- Nerve block to confirm pain.
- Neurohydrolysis to stretch out surrounding tissue.
- Surgery for recalcitrant cases failing to improve after six months.

 SUMMARY

- Nerve entrapments around the shoulder are commonly overlooked.
- Symptoms may be overlapping with more than one nerve.
- Physical exam findings may be subtle.
- More research is needed to determine best management.
- Consider diagnostic evaluation of brachial plexus and cervical plexus before considering surgery for those patients presenting with both shoulder and neck pain.