American Academy of Physical Medicine and Rehabilitation

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EMG Case No. 75, September 2005

Presenting Symptom(s):

Burning pain and weakness of left upper extremity

This case is no longer available for CME credit.

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Disclosures: C. Crooks, None.

Appropriate Audience: Residents and practicing physicians.

Learning Objectives: After completing this educational activity, participants will be able to: (1) Consider brachial plexus injury after trauma involving stretch or pull across shoulder and neck; (2) Formulate guidelines for electrodiagnostic evaluation of upper trunk brachial plexus and localization of lesion; (3) Predict recovery of injuries using a combination of clinical and electrodiagnostic evaluations.

History

M.T. is a 45 year old right-handed gentleman who works as a machine repairman and was involved in a motorcycle accident August 2003. He was admitted a few days after the accident for a work-up regarding arrhythmias. On follow-up with his primary care physician a couple weeks later, M.T. reported pain in his left arm from his axilla to his wrist and numbness over the ulnar side of his hand. He denied weakness, but the primary care physician documented mild weakness likely due to pain inhibition. His past medical history is remarkable for regular tobacco and ethyl alcohol usage.

- Prior to continuing, please develop a differential diagnosis and list each possible diagnosis in order of likelihood.
- Is there any additional information regarding the clinical history that might be helpful in clarifying your differential list or changing its order of priority?

Commentary I

At this point, M.T.'s major issues involve pain, numbness, and tingling in his left upper extremity. The distribution of his sensory complaints is not well localized. We also see a suggestion of weakness, but the weakness is suspicious for being associated with pain inhibition. Therefore, our differential diagnoses remain broad.

First, musculoskeletal causes of his symptoms must be considered. At this time, M. denies weakness other that that which is pain inhibited. Sensory deficits cannot at this point be localized to nerves or roots and is poorly described in terms which imply neurologic etiology.

Second, we must consider brachial plexus injury given the fact that his symptoms coincide with a motorcycle accident in which a stretch and pull across the brachial plexus seems reasonable. At this point it is difficult to localize a brachial plexus injury based on his symptoms. His symptoms incorporate primarily sensory abnormalities, although he did

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report subtle elbow flexion weakness which may have been pain inhibited, and the sensory complaints as documented may incorporate all trunks and cords of the brachial plexus.

Thirdly, ulnar and/or median nerve mononeuropathy must be considered given his employment as a machine repairman and complaints of hand numbness. Entire hand numbness is often reported by those with median nerve mononeuropathy. We should also consider ulnar nerve involvement, including dorsal ulnar cutaneous nerve involvement, because his most prominent numbness was previously reported over the ulnar side of his hand.

Lastly, radiculopathy could cause many of his symptoms, but localization to one or two roots may be difficult. If his symptoms are located over both his lateral and medial arm and forearm, we would have to consider roots C5 through T1. Numbness over the ulnar side of his hand would correspond with involvement of the C8 root. Possible biceps weakness implies possible C5 root involvement.

To better prioritize our differential diagnosis and localize a lesion(s), it would be beneficial to obtain a more detailed history involving the mechanism of injury including the biomechanics of his body's movements and its impact during his accident. In addition, more quality descriptions of his sensations with better localization of sensory symptoms could help differentiate musculoskeletal pain from neurologic pain. Further investigation regarding possible weakness may also be beneficial.

History, continued

Ten days later when he presented to physiatry, M.T. describes his motorcycle accident and explains that he lost consciousness after striking his neck and left shoulder against the van with which he collided. He expanded on his physical symptoms to include more noticeable elbow flexion weakness. He also described a burning pain over his lateral left arm and forearm. He continued to report good finger movements and coordination.

- If necessary, revise your differential diagnosis based on the additional clinical history.
- On which details of the physical examination should you focus at this point?

Commentary II

We must now place brachial plexus involvement more confidently at the top of our differential diagnosis. By the description of his accident, a stretch and pull across the brachial plexus seems likely. His sensory symptoms are now described more reliably in terms which imply neurogenic etiology. In addition, his symptoms now definitely incorporate both sensory and strength deficits. With this information, localizing a possible brachial plexus injury becomes reasonable. The elbow flexion weakness implies musculocutaneous nerve injury which is formed from the lateral cord and upper upper trunk of the brachial plexus. **(See Figure 1)** The primary sensory symptoms appear to incorporate the axillary nerve, lower lateral cutaneous nerve of the arm, and lateral cutaneous nerve of the forearm which are formed primarily from components within the upper trunk of the brachial plexus.

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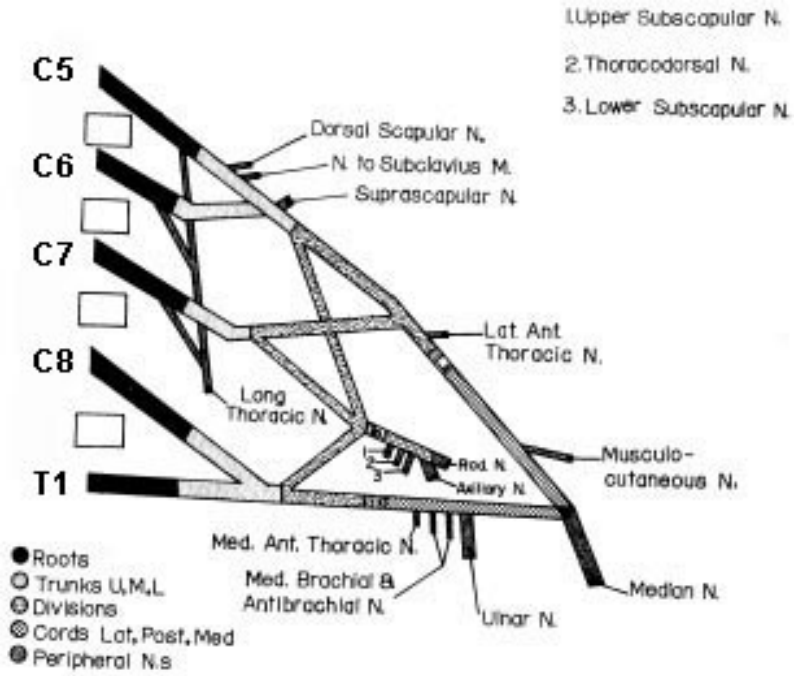
Figure 1. Diagram of the brachial plexus.



Radiculopathy now becomes more likely because we can isolate symptoms primarily to only the C5 and C6 roots. We can now move radiculopathy up to second on our differential diagnoses list.

Purely musculoskeletal causes for his symptoms have now become least likely given the discoveries and associations mentioned above. In addition, median and/or ulnar nerve mononeuropathy become less likely because he continues to report good function and coordination of his fingers.

Our physical examination should focus on localizing weakness and sensory deficits. Muscles should be isolated for manual muscle testing. Deep tendon reflexes should also be evaluated. In addition, general musculoskeletal examination should be performed.

Physical Examination

His muscle strength testing on the right upper extremity and the bilateral lower extremity was rated 5/5. He had noted atrophy of his left deltoid, infraspinatus, and supraspinatus muscles. Physical examination of his left upper extremity revealed palpable contraction (strength rated 1/5) in his supraspinatus, but no palpable contraction is in the infraspinatus muscle (strength rated 0/5). There is no palpable contraction of the deltoid during attempted shoulder forward flexion, extension, or abduction. Contraction of the biceps is palpable (strength rated 1/5), but the muscle is atrophic. Elbow extension strength was rated 4/5. Wrist extension, grip strength, and finger abductor strength was 5-/5, limited by the pain.

His reflexes in bilateral lower extremities and right upper extremity were 2+. He had decreased reflexes in his left upper extremity biceps and triceps. On sensory examination, he has good sensation to light touch and pinprick in all digits of his left hand including his

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thumb. He has 2-point discrimination of about 4 mm in his left thumb. He was able to sense pressure with pinprick stimulation over his proximal lateral shoulder. Sensory to light touch was diminished in his left lateral upper and lower arm. Sensation was normal in his left hand.

Apprehension sign of the left shoulder was positive and not improved with anterior to posterior pressure. Neer's sign was positive on the left. Cross arm adduction was positive on the left. Modified Hawkin's was negative on the left. He had a 2-1/2 cm gap on his left shoulder indicating a positive sulcus sign. He was nontender over the spinous processes.

- At this point, review your differential diagnosis and revise as appropriate.
- Are there additional observations on physical examination that might be helpful in narrowing your differential list?

Commentary III

Although his musculoskeletal exam has positive signs of impingement and irritation, his exam definitely indicates neurologic etiology. There is focal weakness that was not well defined at his initial presentation and the pattern of sensory complains has changed. There is no longer concern of ulnar or median nerve mononeuropathy due to lack of weakness or sensory deficits distally in his left hand.

Although radiculopathy must still be considered, it becomes less likely because there is definitely involvement of multiple roots including C5, C6, and C7. The proximal weakness of shoulder abduction, flexion, and extension in addition to elbow flexion incorporate C5 and C6 involvement. His sensory exam also implies C5 and C6 involvement. C7 involvement is implied given the decreased triceps deep tendon reflex and strength.

Brachial plexus injury remains most likely and can now be better localized. See Figure 1. The biceps muscle is innervated by the musculocutaneous nerve which branches from the lateral cord which is formed from the anterior divisions of the upper and middle trunks. More proximal involvement of the brachial plexus is likely, however, because we appreciate involvement of the suprascapular nerve; the supraspinatus and infraspinatus muscles are atrophied and weak. This nerve branches from the upper trunk and is formed from contributions of C5 and C6 roots.

Further physical examination may include evaluation of scapular winging to provide insight as to whether the rhomboids and/or serratus anterior muscles have been affected. The involvement of either of these muscles would imply more proximal involvement at the root level of the brachial plexus. Further evaluation of forearm pronation, forearm supination, and wrist flexion strength would be interesting but may not contribute to further localization of injury. We already assume from his good wrist extension that he has minimal involvement of the posterior cord or middle trunk. However, further evaluation of pronation, supination, and wrist flexion could solidify these findings because they involve the middle trunk with contributions to all cords within the brachial plexus.

Physical Examination, continued

Further physical examination revealed no scapular winging. He had no palpable contraction of the brachioradialis or evidence of supinator muscle function. He had weak (strength rated 1/5) forearm pronation and contraction of the pronator teres was palpable. He had good

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wrist extension strength (rated 4+/5) and excellent strength (rated 5/5) of his wrist flexion, finger flexion, and finger abduction.

- If necessary, revise your differential diagnosis based on the additional physical findings.
- Design your approach to the electrophysiologic examination based on the existing data.

Commentary IV

Based on the additional physical examination data, we can assume that the lesion is distal to the take-off of the long thoracic and dorsal scapular nerves from the roots. Therefore, our lesion likely lies within the area of the brachial plexus trunks. In addition, the weak pronation and supination imply a greater degree of middle trunk involvement than previously suspected.

Our electrodiagnostic evaluation should concentrate of confirming our clinical suspicions of brachial plexus upper and middle trunk injury. This will likely be accomplished by evaluating the same muscles we have physically examined. It is advisable to perform needle examination of the serratus anterior when considering lesions at the C5, C6, C7 root levels.

Standard nerve conduction studies involving median sensory to the index finger and ulnar sensory to the little finger will not evaluate involvement of the upper trunk. Therefore, nerve conduction studies should incorporate the lateral antebrachial cutaneous and/or the median sensory nerve to the thumb in order to evaluate the upper trunk. A convenient evaluation method includes median and radial sensory studies recorded over the thumb. The median sensory response recorded over the thumb incorporates the upper trunk and medial cord, while the radial sensory response over the thumb incorporates the upper trunk and posterior cord. In addition, because of his marked biceps brachii involvement, we may consider nerve conduction study of the musculocutaneous motor response. If any nerve conduction study results are on the low side of normal, the other side should be evaluated for comparison. In general, a side-to-side difference in amplitude of 50% can be called abnormal even if the values are within normal standard reference ranges.

Electrophysiologic Data

NR = no response

MOTOR NERVE CONDUCTION STUDIES							
NERVE	**SIDE**	**STIM SITE**	**RECORD**	**cm**	**AMPL**	**LAT**	**CV**
Median Motor	L	Wrist	APB	7	4.6	3.8	
Median Motor	L	Elbow	APB	20	3.5	7.8	50
Ulnar Motor	L	Wrist	ADQM	7	12.7	2.5	
Musculocutaneous Motor	L	Axilla	Biceps	10	0.7	3.3	
Musculocutaneous Motor	R	Axilla	Biceps	10	4.7	3.2	

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SENSORY NERVE CONDUCTION STUDIES							
NERVE	**SIDE**	**STIM SITE**	**RECORD**	**cm**	**AMPL**	**LAT**	**CV**
Median Sensory	L	Wrist	Index	14	21.0	3.7	56
Median Sensory	R	Wrist	Index	14	33.0	3.8	44
Median Sensory	L	Wrist	Thumb	14	10.5	2.8	61
Median Sensory	R	Wrist	Thumb	14	22.0	3.7	58
Ulnar Sensory	L	Wrist	Little	14	31.0	3.5	49
Lateral Antebrachial cutaneous	L	Elbow	Forearm	14	5.1	3.8	48

NEEDLE ELECTROMYOGRAPHY

INSERtional activity: N, sust, unsust
FIB: 0, 1+, 2+, 3+, 4+
OTHer: 0 or fascic, myotonia, myokymia
EFFort: N, decr
RECruitment: N, inc or dec 1+, 2+, 3+, 4+
AMPlitude: N, inc or dec 1+, 2+, 3+, 4+
DURation: N, inc or dec 1+, 2+, 3+, 4+
POLyphasia: N, inc or dec 1+, 2+, 3+, 4+

R/L	**MUSCLE**	**INSER**	**FIB**	**OTH**	**EFF**	**REC**	**AMP**	**DUR**	**POL**
L	Biceps Brachii	Sust	4+	0	N	0			
L	Deltoid, middle	Sust	3+	0	N	0			
L	Deltoid, posterior	Sust	3+	0	N	dec 4+	N	inc 2+	inc 2+
L	Supraspinatus	Sust	3+	0	N	0			
L	Serratus Anterior	N	0	0	N	N	N	N	N
L	Triceps	Sust	1+	0	N	dec 1+	N	N	inc 1+
L	Rhomboids	N	0	0	N	N	N	N	N
L	Flexor Carpi Radialis	N	0	0	N	dec 1+	inc 1+	N	inc 1+
L	Flexor Digitorum Interosseous (hand)	N	0	0	N	N	N	N	N
L	Paraspinals, mid cerv	N	0	0					

- On the basis of both the clinical and electrophysiologic evaluations, formulate your diagnostic impression. List the most likely diagnosis first and follow in order with the other possibilities that are not excluded by the data. Eliminate those diagnoses not supported by the data.

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- Are there additional electrophysiologic data that you feel would further delineate the diagnosis? (Remember, collecting data that are not needed for the diagnosis is costly and uncomfortable for the patient.)

Electrophysiologic Data, continued

The nerve conduction studies demonstrate a small median sensory amplitude response recorded over the thumb on the left, and this response is also more than 50% smaller than the response recorded on the right. If the response had been within normal limits, we could still consider it abnormal based on the asymmetry observed. This asymmetry is seen to a lesser degree (40%) when comparing the median sensory response recorded over the index fingers. The response over the index finger incorporates both upper and middle trunks of the brachial plexus, while the response recorded over the thumb incorporates only upper trunk contributions. Therefore, if the lesion is located at the level of the trunks, we can begin to assume that the middle trunk may be less affected by his injury than the upper trunk. However, both of these responses incorporate lateral cord contributions, and based on these nerve conduction abnormalities we cannot differentiate lateral cord from upper trunk lesions. The other small amplitude response seen in the musculocutaneous motor response also incorporates the lateral cord and upper trunk. The other nerves tested were normal and incorporate the medial cord and lower trunk. Therefore, based on our nerve conduction testing alone, we have data to support either an upper trunk lesion with a secondary middle trunk lesion, or possibly a lateral cord lesion. The posterior cord has not been tested during the nerve conduction portion of the electrodiagnostic examination.

Testing the lateral antebrachial cutaneous nerve demonstrated a small amplitude response. This is similar to the finding in the musculocutaneous motor nerve response. The radial sensory response recorded over the thumb is often performed to evaluate the posterior cord, but it also incorporates the upper trunk. Therefore, the suspected upper trunk lesion would also produce small amplitudes in this response. Therefore, the nerve conduction testing evaluation in this case is complete and we will rely on the needle examination to definitively localize the lesion.

Needle examination confirms abnormalities in those muscles innervated by the upper and middle trunks of the brachial plexus. Although these muscles also involve the lateral and posterior cords, involvement of the supraspinatus implies the lesion is proximal to the cords. Examination of the abductor pollicis brevis would have provided information regarding the lateral and medial cords while incorporating only lower trunk contributions. The normal flexor digitorum interrosseous examination does support the lack of medial cord and lower trunk involvement.

There is no longer any evidence to support root lesion(s) given the normal serratus anterior, rhomboid and mid-cervical paraspinals needle examination. In addition, standard median and ulnar nerve testing did not reveal any evidence of mononeuropathy. Therefore, our electrodiagnostic testing has supported our clinical evaluation of an upper trunk brachial plexus injury.

- Make the final revisions of your diagnostic impression(s).

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Diagnostic Impression

Overall, electrodiagnostic studies demonstrate evidence of a severe left brachial plexopathy primarily involving the upper trunk, with less severe involvement of the middle trunk. These results confirm our clinical determinations. In addition, because nerve continuity to the biceps or supraspinatus could not be demonstrated, the data also brings into question the possibility of superimposed suprascapular nerve and/or musculocutaneous nerve injuries.

The data can be further analyzed to provide prognostic information regarding axillary nerve recovery. The nascent units seen in the posterior deltoid implies active axonal regeneration and/or re-innervation. Therefore, we anticipate that the re-innervation of the middle deltoid by the axillary nerve will follow after further re-innervation of the posterior deltoid. Testing must be done at a later date to evaluate possible re-innervation of the supraspinatus and biceps brachii.

- What other diagnostic procedures (laboratory tests, etc.), if any, are needed?
- What treatment would you recommend?

Commentary V

Needle examination continued to demonstrate no continuity to the infraspinatus, and therefore a spinal accessory to suprascapular nerve transfer was performed about seven months after the initial electrodiagnostic testing. Multiple follow-up electrodiagnostic evaluations did not demonstrate enlarging median sensory and musculocutaeous motor amplitude responses until at least one year had passed. Currently, about two years after his motorcycle accident, re-innervation is demonstrated in the supraspinatus, infraspinatus, biceps brachii, coracobrachialis, and posterior deltoid. Despite continued re-innervation of the posterior deltoid, there is no clinical or electrodiagnostic evidence that the middle deltoid is being re-innervated. He continues clinically to have little to no left should abduction but he now has antigravity elbow flexion strength. Because the posterior deltoid is actively being re-innervated, we continue to anticipate middle deltoid re-innervation and the return of active shoulder abduction. He is scheduled to follow-up with further electrodiagnostic testing.

Bibliography

1. Preston, DC; Shapiro, BE. *Electromyography and Neuromuscular Disorders: Clinical-Electrophysiologic Correlations, 2nd Ed*. Elsevier Butterworth Heinemann, 2005