T1 Radiculopathy: Electrodiagnostic Evaluation

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Abstract Electromyography (EMG) studies are useful in the anatomical localization of nerve injuries and, in most cases, isolating lesions to a single nerve root level. Their utility is important in identifying specific nerve-root-level injuries where surgical or interventional procedures may be warranted. In this case report, an individual presented with right upper extremity radicular symptoms consistent with a clinical diagnosis of cervical radiculopathy. EMG studies revealed that the lesion could be more specifically isolated to the T1 nerve root and, furthermore, provided evidence that the abductor pollicis brevis receives predominantly T1 innervation.

Keywords electromyography · EMG · electrodiagnostics · T1 radiculopathy · abductor pollicis brevis (APB) · T1-T2 disc herniation

Introduction

Neurological deficits involving the cervical nerve roots (C5–T1) supplying the upper extremities are a common indication for obtaining electromyographic studies. However, radiculopathies involving the first thoracic nerve root (T1) are reported to be the least common with <1% of cervical root lesions identified at T1 [1, 2]. One confounding reason may simply be that most comprehensive studies investigating cervical radiculopathy exclude T1 nerve root pathology from their analysis [3]. This may be due in part to the fact that common medical teaching of upper extremity myotomal innervations merges C8 and T1 nerve root levels and does not specifically assign any individual muscle to be predominantly T1. In the following case, further proof is provided to support a growing body of evidence that the

abductor pollicis brevis is predominantly innervated by the T1 nerve root level [3–8].

Case report

A 63-year-old male presented with 6-week history of right-sided neck–arm pain and numbness after hauling heavy loads. At the time of injury, the patient reports progressive achiness at the right periscapular region followed by radiating pain and numbness down the medial aspect of the right upper extremity. Paresthesias were noted predominantly in the right fourth and fifth digits with subjective complaints of loss of dexterity in the right hand manifesting as occasionally dropping objects and deterioration of penmanship.

The patient reported no weakness, sudden trauma, prodromal illness, or previous injury. His symptoms are relatively unchanged from the onset of injury. Activities of daily living have been modified to decrease or avoid painful activities or movements. Certain cervical positions, especially neck flexion, exacerbate both pain and numbness sensations. For the past 6 weeks, he has tried relative rest and chiropractic treatments with little change in symptomology.

On general examination, the patient presented as a well-nourished age-appropriate individual with normal gait. Inspection revealed no gross evidence of deformity or atrophy of the posterior spine and shoulders. There was otherwise normal muscle bulk and tone in bilateral upper extremities with no fasciculations. There was also no evidence of Horner's syndrome.

Range of motion examination of the cervical spine revealed full lateral bending and rotation with minimally decreased range in flexion and extension with end range axial lower neck pain. Spurling's maneuver to the right reproduced concordant pain with exacerbation of radicular symptoms down the right upper extremity. There were no positive signs of impingement on examination of the right shoulder. Strength examination revealed 4/5 strength on right thumb abduction and 5/5 strength in all other muscles

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Table 1 Nerve conduction values of sensory nerves

Nerve	Site	Onset lat (ms)	Norm onset	Amplitude	Norm amp	Duration (ms)	Seg name	Distance (cm)	Velocity (m/s)	Norm vel
L med/antbr	Forearm									
	Abv elbow	1.7		10.9			Abv elbow–forearm	9.0	52.9	
R med/antbr	Forearm									
	Abv elbow	1.3		10.5			Abv elbow–forearm	8.5	65.4	
L median	Second digit									
	Wrist	3.2	<3.2	20.2	>10					
R median	Second digit									
	Mid palm	1.4		15.2		1.4	Mid palm–second digit	8.0	57.1	>45.0
	Wrist	3.2	<3.2	16.6		1.8	Wrist–mid palm	8.5	47.2	
L ulnar	Fifth digit									
	Wrist	2.7	<3.2	30.1	>10	2.7	Wrist–fifth digit	0.0		
R ulnar	Fifth digit									
	Palm	1.6		22.1		1.6	Palm–fifth digit	8.0	50.0	
	Wrist	2.7	<3.2	22.4	>10	1.1	Wrist–palm	7.0	63.6	>45

of both upper extremities. Sensation examination was diminished over the medial aspect of the right arm extending into the medial hand. Reflexes were present and symmetric at bilateral biceps, brachioradialis, and triceps. Phalen's maneuver and Tinel's sign were negative. There were no myelopathic signs on examination.

Electromyographic study was performed 6 weeks after onset of symptoms. Nerve conduction studies of sensory nerves were normal and symmetric (Table 1). The importance of this finding reflects relative continuity of sensory neurons originating in the dorsal root ganglion distally to the hand at the point of the recording electrodes. This would indicate that a postganglionic lesion or injury is not present and, if a lesion does exist, it would be preganglionic. Furthermore, this normal finding demonstrates no evidence of median or ulnar sensory nerve compression at the hand or wrist, essentially ruling out a median mononeuropathy at the wrist which would indicate carpal tunnel syndrome.

Motor nerve studies revealed mildly prolonged distal onset latency and severely reduced amplitude of the right median motor nerve (Table 2). This finding points to an underlying axonal loss which may have occurred anywhere between the anterior horn cells within the spinal cord to the distal recording motor site. The degree of axonal loss could explain the mildly prolonged median motor distal latency due to unreliable determination of accurate onset or, alternatively, it may have been secondary to a mild, clinically insignificant, median mononeuropathy at the wrist

consistent with carpal tunnel syndrome. The muscle tested in this median motor examination was the abductor pollicis brevis with reported C8–T1 nerve root innervation. However, the normal sensory conduction study suggests that the site of injury was between the anterior horn cell and the dorsal root ganglion.

Electromyographic needle examination revealed abnormal spontaneous activity in the form of positive sharp waves and fibrillations in C8–T1 innervated muscles (Table 3). The right abductor pollicis brevis revealed the most noted abnormal changes in the form of severe spontaneous activity, discrete recruitment pattern, and decreased recruitment interval. The right first dorsal interosseus, flexor carpi ulnaris, and abductor digiti minimi muscles revealed mild abnormal spontaneous activity and normal recruitment pattern. There was also mild abnormal spontaneous activity at the right lower cervical paraspinal muscles. All remaining muscles innervated by cervical nerve roots cranial to C8 showed no abnormal spontaneous activity, normal motor unit configuration, and normal motor unit recruitment. These electrodiagnostic studies are consistent with a severe right C8 but, more likely, T1 radiculopathy predominantly involving the anterior ramus division.

A cervical spine MRI was performed to examine the cervical nerve roots. This study demonstrated a right posterolateral and foraminal disc extrusion 4 mm in AP length at the T1–T2 intervertebral level (Fig. 1). Further-

Table 2 Nerve conduction values of motor nerves

Nerve	Site	Onset lat (ms)	Norm onset	Amplitude	Norm amp	Duration (ms)	Seg name	Distance (cm)	Velocity (m/s)	Norm vel
R median	Wrist	4.2	<3.6	0.7	>4		Pron ter–wrist	25.0	51.0	>50.0
	Pron ter	9.1		0.5						
R ulnar	Wrist	2.8	<3.6	3.8	>3			24.0	53.3	>50.0
	Abv FCU	7.3		3.1			Abv uln grv–abv FCU	12.0	50.0	>50.0
	Abv uln grv	9.7		3.1						

Table 3 Electromyographic needle examination

Side	Muscle	Nerve	Root	INS	FIBS	PSW	FAS	AMP	DUR	Configuration	PAT	REC INT
R	AbdPollBrev	Median	C8–T1	Nml	2+	3+	0	Nml	Nml	Di/Tri phasic	Discrete	Dec
R	1stDorInt	Ulnar	C8–T1	Nml	1+	1+	0	Nml	Nml	Di/Tri phasic	Full	Nml
R	FlexCarRad	Median	C6–7	Nml	0	0	0	Nml	Nml	Di/Tri phasic	Full	Nml
R	LatHdTriceps	Radial	C6–7	Nml	0	0	0	Nml	Nml	Di/Tri phasic	Full	Nml
R	Biceps	Musc	C5–6	Nml	0	0	0	Nml	Nml	Di/Tri phasic	Full	Nml
R	Deltoid Mid	Axillary	C5–6	Nml	0	0	0	Nml	Nml	Di/Tri phasic	Full	Nml
R	ExtIndicis	Radial	C7–8	Nml	0	0	0	Nml	Nml	Di/Tri Phasic	Full	Nml
R	FlexCarUln	Ulnar	C8–T1	Nml	1+	1+	0	Nml	Nml	Di/Tri phasic	Full	Nml
R	ABDDigMin	Ulnar	C8–T1	Nml	1+	1+	0	Nml	Nml	Di/Tri phasic	Full	Nml
R	CervPara Up	Rami		Nml	0	0	0	Nml	Nml	Di/Tri phasic		
R	CervPara Mid	Rami		Nml	0	0	0	Nml	Nml	Di/Tri phasic		
R	CervPara Low	Rami		Nml	0	1+	0	Nml	Nml	Di/Tri phasic		

more, there was no significant pathology related to the C8 nerve root at the C7–T1 disc level. The findings at that level were minimal with only a mild central disc bulge.

Based on the history, physical exam, electrodiagnostic studies, and the MRI, the final diagnosis arrived at was right posterolateral T1–T2 intervertebral disc protrusion causing clinically significant right T1 radiculopathy.

After discussion of potential treatment options, the patient chose to undergo conservative management. The patient was subsequently referred to physical therapy for postural exercises and retraining, manual chin retractions, anterior chest wall stretching, shoulder retractions, and soft tissue massage to improve segmental motions.

Discussion

Thoracic disc herniation is a rare condition that occurs in only about 1% of all disc herniations [9–11]. When they do

occur, they are typically found in older patients and are predominantly found in the lower thoracic spine [11–13]. The most common disc level for thoracic disc herniation was found to be the T11–12 level with 26–50% of the total number [14–16]. A classic study reviewing the occurrence of 258 thoracic disc herniations found the majority (66%) occurred in the lower third of the thoracic spine (between T9–10 and T12–L1), then middle third (28% between T5–6 and T8–9), followed least by the upper thoracic spine (6% between T1–2 and T4–5) [17]. Of the small number of thoracic disc herniations that occur at the upper third thoracic level (between T1–2 and T4–5), T1–2 is the most common [17].

Thoracic disc disease and diabetes mellitus represent two of the most frequent etiologies for the development of thoracic radiculopathy [18]. Degeneration is favored as the prevailing cause for thoracic disc herniation, and the lower thoracic segments are most at risk because of the increased motion present at these levels [19]. When thoracic disc

Fig. 1. Cervical MRI shows right posterolateral T1–T2 intervertebral disc protrusion. **a** Sagittal image of cervical MRI demonstrating T1–T2 disc protrusion (arrow). **b** Axial image of cervical MRI demonstrating T1–T2 intervertebral disc (asterisk) with right posterolateral protrusion (arrows)

herniations do occur, they occur either in a posterior-central or a posterior-lateral direction [20]. At the upper thoracic levels, one reason for more lateral disc herniation may be due to the absence of Luschka joints beginning at the C7–T1 level [21].

There are many theoretical reasons for the decreased incidence of clinically significant thoracic disc herniations including the fact that disc heights tend to be smaller and discs have less volume [19]. It may also be due to decreased weight bearing loads in flexion and extension, as the primary movements of the thoracic spine are rotation and lateral bending [22]. Regarding certain cases of T1–2 intervertebral disc herniation, reports indicate a causal relationship secondary to increased mechanical stresses following postsurgical treatment at the cervical levels [23, 24].

The literature regarding symptomatology of T1 herniated disc radiculopathy supports the findings of this case, as well as rarer type presentations. Studies have reported cases of paraparesis and myelopathy [25, 26]. However, typical reports include symptoms of hand weakness and pain along the medial arm [4, 27–30]. Also, considering possible T1 contribution to the sympathetic trunk, there are reported cases of oculosympathetic paralysis or Horner's syndrome [27, 28, 31]. An isolated case of a patient with chronic chest pain underwent an exhaustive medical workup before the etiology was attributed to a T1–2 disc herniation compressing the T1 nerve root [24].

In this case, electromyography assisted in the diagnosis of a T1 radiculopathy with findings that support a predominant T1 innervation to the abductor pollicis brevis. The finding of significantly decreased motor amplitude of the median nerve points to an underlying axonal lesion affecting the C8–T1 myotome. Furthermore, the spontaneous activity found in C8–T1 innervated muscles (first dorsal interosseus, flexor carpi ulnaris, and abductor digiti minimi) point to a C8 and T1 distribution as well as the spontaneous activity found in the lower cervical paraspinals. The abnormal spontaneous activity in the lower cervical paraspinal muscles can be debated as to their nerve root etiology. There is considerable nerve root overlap in paraspinal innervation and the abnormal spontaneous activity in the lower cervical paraspinals could originate from either C8 and/or T1 nerve root levels. However, the robust findings of severe abnormal spontaneous activity and decreased recruitment pattern–interval of the abductor pollicis brevis supports a T1 radiculopathy. This, in light of a disc herniation at the T1–2 intervertebral level, supports the growing body of evidence that the APB is primarily T1 innervated [3–8].

In summary, the traditional nomenclature of myotomal distribution of the upper extremity links C8 and T1 nerve roots when describing the muscular innervations of the forearm and hand. There are no classically taught innervations that assign any muscle of the upper extremity with mainly T1 innervation. The electrophysiologic findings in this case help purport the more

accepted claim that the APB is the only muscle in the upper extremity with chiefly T1 innervation.

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