Ultrasonographic and Surgical Findings of Acute Radial Neuropathy Following Blunt Trauma

ABSTRACT


Ultrasonographic study is useful for decision making of treatment for focal neuropathy with unusual electrodiagnostic findings. We present a patient with severe acute radial neuropathy with sensory sparing around the distal arm secondary to twisting of the radial nerve following blunt trauma. A 24-year-old man with a 2-week history of left wrist drop and severe pain around the left elbow presented after hitting the left distal arm on the doorknob. The left wrist and finger extensions were grade 0, but elbow extension could not be tested because of severe pain during this action. The left superficial radial sensory territory was intact. Electrodiagnostic findings suggested severe left radial neuropathy around the distal arm with sensory sparing. Ultrasonographic study demonstrated 2 stenotic lesions around the distal arm and absence of the left superficial radial sensory nerve. Surgical exploration revealed 2 stenotic lesions with twisting of the nerve, concordant with ultrasonographic study. End-to-end anastomosis was performed in the proximal lesion. Sixteen months later, wrist and finger extension was grade 3, and reinnervation signs in the radial-innervated muscles except extensor indicis muscle were observed. The complementary relationship between electrophysiologic and ultrasonographic examinations is very important for precise lesion location and decision making for treatment of peripheral nerve injury.

Key Words: Radial nerve, Neuropathy, Trauma, Ultrasonography, Surgery
Ultrasonographic examination for radial nerve palsy following humerus fracture is especially very useful for evaluating nerve continuity or detecting nerve compression by a bony fragment or callus.4,5

We present a patient with severe elbow pain and difficult elbow extension that was related with severe acute radial neuropathy with sensory sparing around the distal arm secondary to twisting of the radial nerve following blunt trauma.

CASE REPORT

A 24-year-old man with a 2-week history of left wrist drop and severe pain around the left elbow presented after hitting his left distal arm on a doorknob while lifting a heavy object. He could not extend his elbow because of severe elbow pain during elbow extension. According to the Medical Research Council scale, the left wrist and finger extension revealed grade 0, whereas elbow extension could not be tested because of severe pain during this action. The left elbow, wrist, and finger flexors were normal. Sensation in the left upper extremity including the superficial radial sensory nerve territory was intact. There was no history of medical disease and surgery.

Nerve conduction studies (NCSs) were performed in both upper extremities. The radial motor NCS was performed in the extensor indicis muscle using surface recording electrode according to Falck and Hurme’s6 method, and the superficial radial sensory NCS was done using Mackenzie and DeLisa’s7 method recorded from a major branch over the tendon of the extensor pollicis longus muscle and stimulated 10 cm proximal to the active recording electrode. The left radial motor response was unobtainable, but the left superficial radial sensory response was normal compared with the right (amplitude, 36 μV in the left and 30 μV in the right). The left median and ulnar motor and sensory responses were normal, and needle electromyography (EMG) was performed in the left upper-extremity muscles. Abnormal spontaneous activities and no motor-unit action potential were shown in the left radial innervated forearm muscles including the brachioradialis (Table 1).

Ultrasonographic evaluation was performed around the injured site (SA9900 PRIME; Samsung Medison, Seoul, Republic of Korea). Longitudinal and transverse sonograms of the left radial nerve (Fig. 1B) demonstrated 2 focal stenotic lesions (arrows) at 6 and 7.5 cm above the elbow crease and diffuse swelling compared with the right (Fig. 1A). The left superficial radial sensory nerve could not be found around the elbow, but the right superficial radial sensory nerve was observed as a separate fascicle within the radial nerve.

Surgical exploration revealed 2 stenotic lesions with twisting of the nerve (Figs. 2A, C), concordant with the ultrasonographic findings (Fig. 2D). The proximal lesion was type 4 of Sunderland’s nerve injury classification, in which the epineurium was preserved, but there were no preserved functioning axons in it. For the proximal lesion, the stenotic lesion was resected en bloc, and end-to-end neurolysis was performed under the operating microscope. Limited neurolysis was performed for the mildly stenotic distal lesion, which was decided as type 2 of Sunderland’s classification (Fig. 2B). After the end-to-end neurolysis, the long-arm above-the-elbow splint was applied including the wrist and fingers in extended position to prevent flexion contracture. The splint was maintained for 4 postoperative weeks to protect the neurorrhaphy site. After then, free range of motion of the elbow, wrist, and fingers was permitted with the

### TABLE 1 Serial needle electromyographic examinations

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Initial Test (2 wk After Trauma)</th>
<th>1st Follow-up Test (8 mo After Trauma)</th>
<th>2nd Follow-up Test (16 mo After Trauma)</th>
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<tbody>
<tr>
<td></td>
<td>ASA</td>
<td>MUAP</td>
<td>RP</td>
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<tr>
<td>TB</td>
<td>−</td>
<td>Normal</td>
<td>Full</td>
</tr>
<tr>
<td>BR</td>
<td>++</td>
<td>No MUAP</td>
<td></td>
</tr>
<tr>
<td>ECRL</td>
<td>+</td>
<td>No MUAP</td>
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<tr>
<td>ED</td>
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<tr>
<td>EI</td>
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<td>No MUAP</td>
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</tbody>
</table>

ASA, abnormal spontaneous activities such as fibrillation potentials or positive sharp waves; BR, brachioradialis; ECRL, extensor carpi radialis longus; ED, extensor digitorum; EI, extensor indicis; Max, maximally reduced RP; mod, moderately reduced RP; MUAP, motor unit action potentials; Poly, polyphasic motor unit action potentials; RP, recruitment patterns; TB, triceps brachii.
physiotherapy based on the routine regimen for the radial nerve palsy. His pain disappeared the next day after surgery.

Eight months later, wrist and finger extension revealed grade 2, and reinnervation signs in extensor forearm muscles distal to brachioradialis muscle were observed (Table 1). Sixteen months later, muscle strength of wrist and finger extension recovered to grade 3, and further reinnervation signs were observed in the follow-up needle examination (Table 1). Follow-up radial motor NCSs demonstrated no response 8 months after surgery but small response (distal amplitude, 0.5 mV) 16 months after surgery. A follow-up ultrasonogram (Accuvix V20 Prestige’s ultrasound imaging system; Samsung Medison) showed persistent structural continuity but more diffuse swelling of the left radial nerve (Fig. 1B).

**DISCUSSION**

As the radial nerve remains intact in patients with radial neuropathy following humeral fracture, the prognosis for the radial neuropathy is good.\(^8\,^9\) Therefore, functional splinting or conservative management has been preferred for clinical improvement for 2 to 6 months before exploratory surgery.\(^10\,^11\) However, surgical exploration or delayed operation is generally reserved for cases in which no clinical

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**FIGURE 1** Longitudinal and transverse sonograms of the right (A) and left (B) radial nerves in initial examination show 2 focal stenotic lesions (arrows) at 6 and 7.5 cm above the elbow crease and diffuse swelling compared with the right side. Follow-up ultrasonograms (16 months after surgical intervention) of the left radial nerve demonstrate that its continuity is preserved, but its swelling is increased (C). EC+7, 7 cm proximal to elbow crease; EC+8, 8 cm proximal to elbow crease.
or electrodiagnostic improvement is documented for 3 to 4 months after presentation.\textsuperscript{12,13}

If electrodiagnostic and ultrasonographic tests demonstrate complete axonal nerve injury, such as sharp transection, full-thickness nerve injury (severe axonotmesis and neurotmesis), and clean wound,\textsuperscript{14} immediate surgical exploration and primary repair could be suggested instead of conservative management as an initial treatment.

It is very important to differentiate neuropraxia from axonotmesis in acute stage of peripheral nerve injury. Electrodiagnostic examinations can provide useful information about lesion localization, pathophysiology of the nerve injury (demyelinating or axonal injury), and severity of the nerve injury (incomplete or complete). If complete axonal injury would be suggested based on electrodiagnostic tests, although nerve injury is acute, immediate surgical exploration could be needed. In our case, electrophysiologic findings suggested complete axonal injury of motor fibers in radial nerve around the distal arm with unusual radial sensory fiber sparing. This discrepancy between motor fiber (motor NCS and needle EMG) and sensory fiber (sensory NCS) examinations made it difficult to localize the lesion site. However, ultrasonographic examination provided very important information about morphological changes of the left radial nerve around the distal arm including mild swelling and 2 stenotic lesions. Especially, proximal stenotic lesion was suspected to be transected because of discontinuity of fascicular pattern. Based on the results of the electrophysiologic and ultrasonographic examinations, surgical exploration was decided, which showed that the majority of proximal stenotic lesion was transected with only the epineurium left (type 4 of Sunderland’s nerve injury classification), and the distal stenotic lesion was type 2 of Sunderland’s classification). Our case report demonstrated that combination of electrodiagnostic and ultrasonographic examinations is very important for localizing the precise lesion site and making a decision for surgical exploration and conservative treatment. In fact, they are a best duo for diagnosis and management of peripheral nerve injury.

Unusual electrophysiologic finding was sparing of the superficial radial sensory response in the affected side compared with the electrophysiologic findings for motor function and surgical finding of the radial nerve. One could suspect that the superficial radial sensory nerve was not derived from the radial nerve but rather from other nerves such as the musculocutaneous nerve. There were a few articles about an anatomic variation in which the musculocutaneous nerve replaced the superficial nerve.

**FIGURE 2** Surgical exploration revealed 2 stenotic lesions (A and C, short arrows), concordant with ultrasonographic finding of the left radial nerve (D). The proximal lesion (*) was nearly transected with only epineurium intact. Neurorrhaphy was performed for the proximal lesion with dissection of each ending (arrowheads) (B).
radial nerve. Recently, Davidovich et al. reported a patient with total lesion of the radial nerve in the arm with normal superficial radial sensory action potential, which suggested an anatomical variation in which the lateral antebrachial cutaneous nerve innervates the radial border of the dorsal hand. This anatomic variation might also be able to explain our patient’s superficial radial sensory-sparing issue, although electrophysiologic evaluation was not performed. However, ultrasonographic findings supported the anatomic variation of the superficial radial sensory nerve in the affected side.

In cases of peripheral nerve injury, prognosis for recovery varies with the degree of lesion severity and type of nerve injury. In particular, completely dissected or severely damaged nerve showed a worse prognosis for regeneration. Peripheral nerve injuries requiring surgical intervention had better results the earlier the nerve was repaired after injury. However, if nerve continuity is preserved, spontaneous recovery is likely to occur, as reported by Bodner et al. After surgical intervention, our patient demonstrated clinically good prognosis.

Follow-up electrophysiologic tests showed that reinnervation processes were going. Follow-up ultrasonographic examination revealed preserved continuity, but more diffuse swelling of the nerve. Peer et al. reported that sonographic findings of primary peripheral nerve repair showed a certain amount of spindle-shaped thickening with continuous tapering of the nerve to normal diameter between 1 and 2 above and below that region in the follow-up ultrasonographic examination 11 months after the initial operation. In our case, more diffuse swelling of the radial nerve might be related to various factors such as the massive surgical procedure including en bloc resection of the proximal stenotic lesion (Sunderland class 4 lesion) and end-to-end neurorrhaphy, relative long segment of the lesion (2 stenotic lesions), and axonal regeneration. Although our patient did not show complete recovery in terms of EMG and NCS, early surgical intervention achieved a considerable improvement in terms of clinical diagnosis and hand function.

In conclusion, our study demonstrates the importance of combined electrodiagnostic and ultrasonographic evaluations in peripheral nerve injury. Their complementary relationship provides useful electrophysiologic and anatomical information for precise lesion location and decision making for treatment of peripheral nerve injury.

Supplementary Checklist

CARE Checklist: http://links.lww.com/PHM/A226

REFERENCES


