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Diagnostic accuracy of ultrasonographic and nerve conduction studies in ulnar neuropathy at the elbow

Gregor Omejec, Tomaž Žgur, Simon Podnar *

Institute of Clinical Neurophysiology, Division of Neurology, University Medical Center Ljubljana, Slovenia

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HIGHLIGHTS

- Diagnostic accuracy of high-resolution ultrasonography (US) is lower than of standard 10-cm nerve conduction studies (NCSs) and of short-segment NCSs (SSNCSs).
- US proved to be particularly useful in patients with axonal ulnar neuropathy at the elbow (UNE), while SSNCSs in UNE with conduction block.
- Use of both SSNCSs and US improves the reliability of the diagnosis of UNE, which is particularly important when surgical therapy is contemplated.

ABSTRACT

Objective: To report diagnostic accuracy of ultrasonography (US) and compare it to standard 10-cm nerve conduction studies (NCSs), and short-segment NCSs (SSNCSs) across the elbow in the diagnosis of ulnar neuropathy at the elbow (UNE).
Methods: In a broad spectrum of consecutive patients with suspected UNE a prospective and blinded study was performed. This included a clinical examination, electrodiagnostic (EDx) and US studies. In clinically definite UNE patients we compared the sensitivity of SSNCSs, of 10-cm NCSs across the elbow, and of US. The specificity was calculated in asymptomatic controls.
Results: We studied 113 affected arms in 109 patients; definite UNE was diagnosed in 81, and alternative conditions in 12 arms. The sensitivity of SSNCSs was 89%, of 10-cm NCSs 83%, and of US 71%. We found the highest sensitivity of US in patients with axonal UNE (93%), followed by conduction slowing (82%) and conduction block (55%). Specificity of SSNCSs was 80%, of 10-cm NCSs 82%, and of US 82%.
Conclusion: The present study found the highest diagnostic accuracy of SSNCSs (85%), followed by 10-cm NCSs (83%), and of US (77%).
Significance: US is particularly useful in patients with axonal UNE, while SSNCSs in UNE with conduction block.

1. Introduction

Traditionally ulnar neuropathy at the elbow (UNE) has been diagnosed using clinical examination, and confirmed by electrodiagnostic (EDx) testing. Of EDx techniques standard 10-cm nerve conduction studies (NCSs), demonstrating reduced conduction velocity or conduction block in the elbow segment, are still most often used (Preston and Shapiro, 2013). Although this approach has very high specificity (>95%), it has much lower sensitivity that varied in different studies from 37% to 86% (American Association of Electrodiagnostic Medicine and Campbell, 1999). Another EDx approach useful in diagnosis of focal neuropathies is short-segment NCSs (SSNCs). However, in spite of its higher diagnostic accuracy, only three studies reported diagnostic accuracy of SSNCs in UNE (Azrieli et al., 2003; Visser et al., 2005; Yuksel et al., 2009), which are also rarely used in UNE diagnosis.

In the last two decades important progress has been made in peripheral nerve imaging. Therefore, ulnar nerve can be now depicted with excellent resolution, also using advanced ultrasonographic (US) technology. US has been also recommended as a good

* Corresponding author at: Institute of Clinical Neurophysiology, University Medical Center Ljubljana, SI-1525 Ljubljana, Slovenia. Tel.: +386 1 522 1500; fax: +386 1 522 1533.
E-mail address: simon.podnar@kclj.si (S. Podnar).

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and reliable additional test in the diagnosis of UNE (Beekman et al., 2011). However, US studies measuring ulnar nerve thickness in UNE patients, reported highly variable sensitivity of 46%–100% and specificity of 43%–97% (Ayromlou et al., 2012; Bayrak et al., 2010; Beekman et al., 2004; Gruber et al., 2010; Mondelli et al., 2008; Pompe and Beekman, 2013; Volpe et al., 2009; Yoon et al., 2008). Moreover, up to now only one prospective US study in UNE, designed in full accordance with the Standards for Reporting of Diagnostic Accuracy (STARD) recommendations (Bossuyt et al., 2003), has been published (Beekman et al., 2004). That study used standard 10-cm NCSs and not SSNCSs as a reference test. In addition, although nowadays nerve cross sectional area (CSA) is usually measured in clinical US practice, in that study ulnar nerve diameter was measured (Fig. 1).

In order to better define role of US in UNE diagnosis we performed the prospective study, designed in full accordance with STARD recommendations. We primarily aimed to estimate diagnostic accuracy of US in patients with the diagnosis of UNE established by clinical examination and SSNCSs. In US studies we measured ulnar nerve CSAs using a trace method. Furthermore, we also compared diagnostic accuracy of US to standard 10-cm NCSs and SSNCSs in patients with UNE diagnosis established by clinical examination alone.

2. Materials and methods

2.1. Patients and controls

We prospectively recruited consecutive patients with suspected UNE who were referred to the secondary referral centre (i.e., the Institute of Clinical Neurophysiology, University Medical Centre Ljubljana, Slovenia). Inclusion criteria was at least one of the following presenting symptoms typical for UNE: (1) continuous numbness or paresthesias in the 5th and in the ulnar half of the 4th finger; *or* (2) feeling of weakness or clumsiness of the ulnar-innervated muscles; *or* (3) pain on the medial aspect of the elbow radiating to the forearm or hand. Exclusion criteria were: (1) previous elbow fracture or surgery; *or* (2) known polyneuropathy, symptoms of polyneuropathy, all conditions causing polyneuropathy (e.g., diabetes), hereditary neuropathy with liability to pressure palsies and multifocal motor neuropathy with conduction block (MMN); *or* (3) motor neuron disorders (e.g., monomelic amyotrophy, amyotrophic lateral sclerosis – ALS). In addition, a control group of adults without neurological symptoms or signs in the arms was recruited (Omejec and Podnar, 2014). In all patients, the symptomatic arm was examined. In controls the left arms were generally examined. However, in controls with even remote history of transient left arm symptoms or fractures the right arm was selected, and controls with even remote bilateral arm symptoms were excluded. Four examiners who performed patient evaluation were blinded to the findings of the other parts of the evaluation, and to subject's status (symptomatic or asymptomatic).

The study was approved by the National Ethics Committee of Slovenia, and signed written informed consent was obtained from all subjects prior to the investigation.

2.2. History and clinical examination

The first examiner (AD, EDx technician >20 years) took a short history, collected demographic and clinical data using a focused questionnaire (Mondelli et al., 2006).

The second examiner (TŽ, neurologist >25 years) graded muscle wasting in both hands, estimated muscle strength using Medical Research Council (MRC) scale (Florence et al., 1992), and tested light touch and pin prick.

Based on data on clinical information severity of UNE was divided into 3 levels (1-mild, 2-moderate, 3-severe) as described previously (Bartels et al., 1998).

2.3. Electrodiagnosis (EDx)

The third examiner (SP, clinical neurophysiologist >20 years) performed ulnar NCSs across the elbow with the subject supine, using a standard EMG system (Nicolet Synergy, Natus Medical Incorporated, San Carlos, USA). With the elbow flexed at 90° (Fig. 1), markers were placed at the medial epicondyle (ME), 2 and 4 cm distal (D2, D4), and 2, 4 and 6 cm proximal (P2, P4, and P6) along the course of the ulnar nerve (Kanakamedala et al., 1988). Compound muscle action potentials (CMAPs) were recorded separately from the abductor digiti minimi (ADM) and the first dorsal interosseus (FDI) muscle on stimulation at the wrist, at all elbow markers and for ADM recording also at the Erb point. Median CMAPs recorded from the abductor pollicis brevis muscle on wrist and elbow stimulation, as well as median and ulnar F-waves were also recorded. Ulnar and median antidromic sensory nerve action potentials (SNAPs) from the 4th finger and ulnar SNAPs from the 5th finger were recorded. In all patients and subjects with pathologic NCSs, concentric needle electromyography (EMG) of the ADM, FDI, flexor digitorum profundus 4–5 (FDP 4–5), flexor carpi ulnaris (FCU) and extensor indicis muscles were performed. EMG of additional muscles (e.g., flexor pollicis longus, flexor carpi radialis, etc.), and additional EDx studies were performed when we suspected alternative diagnoses (e.g., ALS, MMN). Furthermore, we confirmed cervical radiculopathies using MRI of the cervical spine, would perform anti-ganglioside antibodies and CSF analysis to confirm MMN, etc.

2.4. Diagnosis of UNE

According to the Standards for Reporting of Diagnostic Accuracy (STARD) recommendations (Bossuyt et al., 2003), patients were divided into three groups (Fig. 2): (1) patients with a clinical diagnosis of UNE (Group I – Clinically definite UNE, Fig. 2): forearm ulnar muscle (FCU, FDP 4–5) weakness + sensory loss in the area of ulnar nerve innervation *or* intrinsic hand ulnar muscle (ADM, FDI) weakness + sensory loss, including the ulnar dorsal cutaneous branch area; (2) patients with other clinical patterns compatible with UNE (Group II – Suspected UNE, Fig. 2) requiring EDx confirmation (e.g., intrinsic hand ulnar muscle weakness + no sensory loss in the ulnar dorsal cutaneous branch area; isolated sensory signs; isolated motor signs); and (3) subjects with normal neurologic examination (Group III – UNE less likely, Fig. 2).

For EDx diagnosis of UNE, SSNCSs across the elbow were utilized (i.e., reference standard) (Azrieli et al., 2003; Visser et al., 2005). UNE was diagnosed when: (1) motor nerve conduction velocity (MNCV) was below the lower reference limit for the appropriate short-segment, *or* (2) CMAP amplitude drop was above the upper reference limit (Table 1). After exclusion of alternative diagnoses, normative limits were used (Table 1) in patients with clinically definite UNE and clinically suspected UNE (Group I and II, Fig. 2). By contrast, more stringent reference limits were used (Table 1) in patients with alternative diagnoses (Group C, Fig. 2), and in subjects with UNE less likely (Group III, Fig. 2) (Omejec and Podnar, 2014). Patients with alternative diagnoses and EDx confirmation of UNE were included in the group of patients with possible UNE (Group F, Fig. 2), while the remaining patients with alternative diagnoses were included in the control group (Group G – patient controls, Fig. 2). The diagnosis of UNE was supported, and in patients with non-localizing EDx findings (e.g., axonal lesion; Group D, Fig. 2) confirmed by neuropathic concentric needle EMG in FCU and FDP 4–5, and normal findings in non-ulnar C8 myotome muscles.