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Research article

High-resolution ultrasound in etiological evaluation of ulnar neuropathy at the elbow

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A R T I C L E I N F O

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A B S T R A C T

Objective: Ulnar neuropathy at the elbow (UNE) involves mechanical compression and irritation of the ulnar nerve (UN) caused by environmental and dynamic abnormalities that can however also be found in asymptomatic patients. Using high-resolution ultrasound, we aimed to assess and compare the relevance of morphological and dynamic variants of the UN and its surrounding structures (UN abnormalities) in symptomatic and asymptomatic patients.
Method: UN abnormalities in patients with UNE were assessed using high-resolution ultrasound and compared against unaffected arms (patients or healthy volunteers).
Results: We studied 234 arms of 117 individuals (89 with UNE and 145 control). Eighty-one percent of the arms with UNE compared to 40% of control ($p = 0.00001$) showed UN abnormalities. While it was dislocated in 49% of arms with UNE compared to in 23% of control ($p = 0.004$).
Conclusion: The two-fold higher frequency of occurrence of UN abnormalities in arms with UNE indicates their causative or at least contributory role in such neuropathies. High-resolution ultrasound should be part of the initial evaluation of UNE in order to assess the etiology of the conflict.

1. Introduction

Ulnar neuropathy at the elbow (UNE), also called cubital tunnel syndrome, is the second most common entrapment neuropathy with an incidence of 24.7 cases per 100 000 persons per year [1]. It affects daily living and quality of life for affected patients. The diagnosis is established upon physical examination and by assessing patient history along with the findings of electrophysiological studies and imaging.

UNE involves mechanical compression and irritation of the ulnar nerve (UN) at the elbow [2]. The exact cause of compression remains unclear and numerous factors have been implicated including UN dislocation (luxation and subluxation) [3], hypertrophy of medial triceps muscle, snapping triceps syndrome [4], presence of an anconeus epitrochlearis muscle [5,6], elbow arthritis [7], posttraumatic and postoperative osseous reorganization [8], and space-occupying lesions such as a lipoma or ganglion [8,9]. However, some of these features can be found in asymptomatic patients [10,11] and their relevance in patients with UNE has never been fully investigated in terms of the relation between such variations and the occurrence of UNE.

The continuous technological evolution of ultrasound imaging has provided the possibility to perform an increasingly accurate study of the anatomical structures of the musculoskeletal system and high-resolution ultrasound is well suited for evaluating the elbow [12].

Here we aimed to use high-resolution ultrasound to compare the prevalence of morphological and dynamic changes of the UN and its surrounding tissues in affected and non-affected arms, in order to evaluate the role of distinguishable features in the constitution of UNE.

2. Methods

2.1. Design and selection

This study was approved by our local ethics committee.

We retrospectively considered all consecutive patients presenting for ultrasound imaging in our institution from the 1 st of January 2010 to the 31 st of December 2013. Patients were included if they suffered from unilateral or bilateral UNE verified clinically by a surgeon and with nerve conduction studies and/or electromyography. Two neurophysiologists with respectively 8 and 12 years of experience performed electrodiagnostic studies and diagnosis of UNE in agreement with the

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American Association of Neuromuscular and Electrodiagnostic Medicine (AANEM) practice parameter for electrodiagnostic studies in ulnar neuropathy at the elbow [13]. Exclusion criteria consisted of: electrophysiological monitoring either not performed or detecting an ulnar neuropathy not localized to the elbow; alternate or confounding diagnoses (such as median neuropathy at the wrist, peripheral neuropathy, concomitant radiculopathy or brachial plexopathy). None of the volunteers included in the control group of the study displayed any clinical signs, symptoms, or history of UNE. The healthy contralateral arm of patients with unilateral UN was included in the control group. Electrophysiological tests were not performed in the healthy volunteers for ethical reasons, nor in the contralateral arm of patients as recommended by the AANEM [13]. Data were gathered using ultrasound reports and medical reports. Age, sex, dominant arm, side of affected arm, duration of symptoms and McGowan stage (three grades according to the severity of the neurological signs: Grade I, minimal lesions with no detectable motor weakness; Grade II, intermediate lesions; Grade III, severe lesions with paralysis of one or more of the ulnar intrinsic muscles [14]) were registered.

2.2. Sonography

The sonographic examinations of the elbow were performed by two musculoskeletal radiologists with respectively 7 and 15 years of experience in musculoskeletal sonography. A linear array transducer with a small footprint and bandwidth of L 5–12 MHz was used with the SonoCT function of the Toshiba TA 700 machine. Focus settings were adjusted at each imaging location in individual patients to obtain optimum images. Patients were examined in the seated position with the palm of their hand on a table (the height of which was just above the patient's hip). Initially, the elbow was flexed to 90° in the direction of the radiologist, with the shoulder abducted and internally rotated by approximately 30°. Then dynamic US of the tunnel was performed while flexing the elbow with the transducer remaining stationary relative to the medial epicondyle (Fig. 1). An ample amount of gel was used with very light probe pressure applied to the skin in order to avoid nerve compression and allow free movement of the nerve during dynamic scanning of the elbow. Both upper limbs were studied in each patient. The cross-sectional area of the ulnar nerve was measured on transversal scans, in the orthogonal position within the echogenic rim surrounding the nerve at the level of the medial epicondyle. Any variation of the structures surrounding the nerve (cubital tunnel) was recorded. These included: the presence of an anconeus epitrochlearis muscle (muscle running from the medial cortex of the olecranon to the inferior surface of the medial epicondyle), hypertrophied medial head of the triceps muscle (medial head of the triceps occupying more than 50% of the surface of the ulnar groove and exerting a mass effect on the ulnar nerve during elbow flexion), space-occupying lesions, osseous abnormalities, osteophytes, cyst, ganglia, or any variation to the normal course of the UN at the elbow. During dynamic examination, we classified the UN into 3 types according to the degree of movement (Fig. 2): no dislocation (type I), subluxation (type II: the nerve moved onto the tip of the epicondyle), luxation (type III: the nerve moved anteriorly beyond the tip of the epicondyle).

2.3. Statistical analysis

Patient information was anonymized prior to analysis. For all descriptive and inferential analyses, an assumed normal distribution of the data was analyzed by the Shapiro and Wilk test as well as by the kurtosis and skewness standardized coefficients. Underlying assumptions of each statistical procedure were tested, and the following tests were consequently used for group comparisons: Student *t*-test, Wilcoxon-Mann-Whitney test, Chi-square test and Fisher's exact test. Mean and 95% confidence intervals were reported for normally distributed variables and median and interquartile range for non-normally distributed variables. The total UN dislocation and total morphological variation were subsequently included in a multiple logistic regression model to determine the independent cause of UNE.

A receiver operating characteristic (ROC) analysis was performed to assess the efficiency of UN cross-sectional area in diagnosing UNE. An optimal cut-off point was assessed by choosing the higher Youden index.

All statistical analyses were conducted using SPSS software 22.1 for Windows (SPSS, Inc, Chicago, IL). All inferential analyses were performed by means of a two-tailed test, with a level of significance of 5%.

3. Results

3.1. Cohort characteristics

A total of 75 patients with UNE and 42 volunteers were included. Fourteen patients had bilateral UNE (19%) resulting in the inclusion of 234 arms comprising 89 with UNE and 145 controls. There was no difference in age, sex, or dominant arm frequency between the two groups (Table 1). Mean initial McGowan scale for patients with UNE was: II ± I. The mean duration of symptoms before diagnosis was 12 months (CI 95% [4,20 months]).

3.2. US findings (Table 2)

Dislocation of UN during elbow flexion appeared in 49% of arms with UNE and in 23% of control ($p < 0.0001$). In addition, we found abnormal surrounding structures in 60% of arms with UNE compared to in 25% of control ($p < 0.0001$). In those with UNE, these structures were: anconeus epitrochlearis muscle (n = 21), hypertrophy of medial triceps muscle (n = 12), accessory head of the triceps muscle (n = 2), post-traumatic osseous reorganization (n = 5), post-operative osseous reorganization (n = 6), prominent osteophytes (n = 3), arteriovenous malformation (n = 1), soft tissue tumor (n = 1), synovial cyst

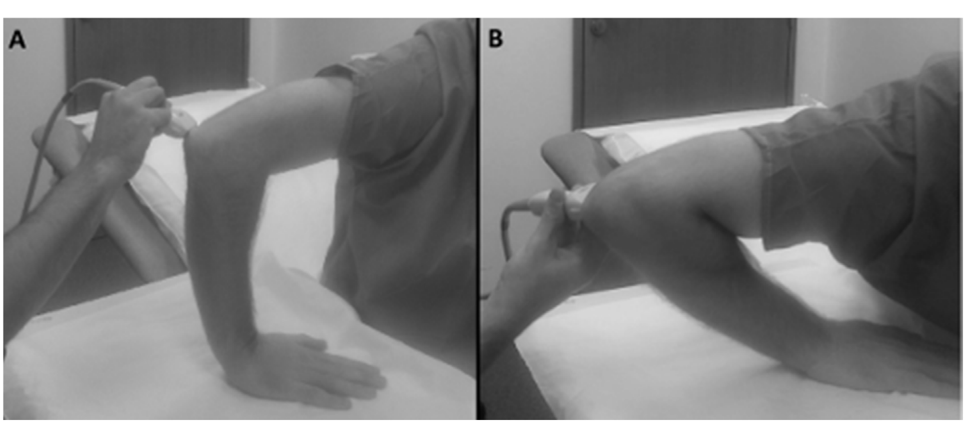

Fig. 1. Ultrasound technique. A: Static exploration of the ulnar nerve and it surrounding structures. Patients were in the seated position with the palm of their hand placed either on their knee or on a table. The elbow was flexed to 90° in the direction of the radiologist, with the shoulder adducted and internally rotated by approximately 30°. B: Dynamic exploration of the ulnar nerve during flexion of the elbow.