Clinical Neurophysiology Practice 2 (2017) 188–191

Contents lists available at ScienceDirect

Clinical Neurophysiology Practice

journal homepage: www.elsevier.com/locate/cnp

Research paper

Standard median nerve ultrasound in carpal tunnel syndrome: A retrospective review of 1,021 cases ☆

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ARTICLE INFO

Article history:
Received 20 March 2017
Received in revised form 26 June 2017
Accepted 2 July 2017
Available online 15 September 2017

Keywords:
Carpal tunnel syndrome
Ultrasound
Screening
Sensitivity
Median nerve
Diagnosis

ABSTRACT

Objective: Carpal tunnel syndrome (CTS) is diagnosed with electrodiagnostic (EDx) studies. Investigations have examined US cross sectional-area (CSA) and wrist to forearm ratio (WFR) cut-offs for screening EDx abnormalities in patients with suspected CTS. The objective of this study is to determine if these US parameters are effective in a real world population.

Methods: This is a retrospective review of patients presenting to the Duke Electromyography (EMG) Laboratory during 2013–2014 with a final diagnosis of CTS. US diagnosis of CTS was based upon median nerve cross-sectional area of >9 mm^2 and/or wrist-to-forearm ratio of >1.4. EDx studies were the gold standard for diagnosis.

Results: A total of 670 patients and 1,021 extremities were studied. US was positive in 97.6% of EDx confirmed CTS.

Conclusion: Median nerve US is nearly as sensitive as the gold standard for EDx testing for the diagnosis of CTS.

Significance: The data here suggest that US may have use as a screening tool prior to performing EDx testing for CTS.

1. Introduction

Carpal tunnel syndrome (CTS) is the most frequent entrapment neuropathy and a common reason for referral to electrodiagnostic (EDx) laboratories. CTS causes pain, numbness, and tingling in the hands and is an important cause of work disability. Several factors have been associated with CTS and include chronic diseases (diabetes mellitus, rheumatoid arthritis, gout, hypothyroidism) or occupational factors associated with forceful and repetitive hand motions, awkward postures, mechanical stress at the base of the palm and vibration (Atcheson et al., 1998; Feldman et al., 1987). The gold standards for diagnosis are based largely on clinical presentation and EDx studies, however at least four studies have provided level I evidence for sonographic visualization of median nerve enlargement as a diagnostic alternative that is painless, non-invasive and inexpensive (Beekman and Visser 2003; Mhoon et al., 2012; Duncan et al., 1999).

CTS is widespread with a prevalence in the general adult population ranging from 2.7% to 5.8% (Atroshi et al., 1999). This condition also carries a high healthcare burden. A 1998 study examined health care expenditures and patterns of work disability by analyzing claims accepted by the US Department of Labor, Office of Workers' Compensation Programs (OWCP), from October 1, 1993, through September 30, 1994. CTS was the most costly diagnosis, accounting for 57% of expenditures. A mean of 84 workdays was lost for CTS and the average cost per patient was $4,941 (Atroshi et al., 1999). Given the frequency of CTS in the general population and its cost to society, inexpensive screening and diagnostic tools would be advantageous.

A prospective trial performed in 2012 at our institution assessed the utility of ultrasound (US) in screening for EDx abnormalities in patients with CTS symptoms. The results of this prospective study demonstrated 99% sensitivity for detecting EDx abnormality in patients with a median nerve cross sectional area

Abbreviations: CTS, carpal tunnel syndrome; CSA, cross-sectional area; EDx, electrodiagnostic; OWCP, Office of Workers' Compensation Programs; US, ultrasound; WFR, wrist to forearm ratio.

☆ Portions of this manuscript were presented at the AAN 2016 Conference in Vancouver, BC, Canada and AANEM 2016 Conference in New Orleans, LA, USA.

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https://doi.org/10.1016/j.cnp.2017.07.004
2467-981X/

(CSA) of >9 mm^2 at the wrist and 97% sensitivity for a wrist-forearm ratio (WFR) of >1.4. There were no clinically significant correlations between US parameters and EDx severity. In this retrospective study, we performed a review of all diagnosed CTS patients evaluated between January 2013 and December 2014 to investigate the utility of our established median nerve US parameters in clinical practice (Mhoon et al., 2012).

2. Methods

The institutional review board of Duke University approved this retrospective study. Informed consent was not obtained, Exempt Research Application and an Application for Waiver of HIPAA Privacy Authorization were obtained.

2.1. Study group

This is a retrospective chart review of all patients who presented to the Duke Electromyography (EMG) Laboratory during January 2013–December 2014. The Duke EMG Laboratory database (ELMS) was queried to identify all patients with a final diagnosis of CTS. Our institutional standard is that CTS is diagnosed based upon EDx studies alone, irrespective of the US findings. However, we have no effective way of retrospectively looking at this data or to determine if the patient had clinical symptoms of CTS. Accompanying EMG findings and US findings were reviewed as described here.

After identifying patients with a final electrodiagnostic diagnosis of CTS, an electronic medical record review was completed on these patients to assess demographics including age, sex, handedness, height, weight, body mass index (BMI) and ethnicity. In addition, the presence of diabetes mellitus, hypertension, pregnancy and thyroid disease was recorded.

In total, 670 patients were included in this analysis. Of the 670 patients, 351 had studies to both upper extremities and 319 only had one extremity examined. Therefore, 1,021 extremity studies were included.

2.2. EDx testing

All nerve conduction studies (NCS) were performed at a skin temperature of 34 °C. For CTS, a minimum of median motor response over the abductor pollicis brevis, median mixed nerve action potential, and ulnar mixed nerve action potential recordings was performed. The median motor nerve conduction study was obtained by placing recording electrodes over the abductor pollicis brevis and stimulating the nerve 6.5 cm proximally at the wrist. Median and ulnar mixed nerve conduction studies were obtained by stimulating the nerves in the palm and recording 8 cm proximally over the respective nerves. A diagnosis of CTS was defined by a distal motor latency of >4.3 ms, a median mixed nerve latency of >2.2 ms, or a difference between median and ulnar mixed latencies of ≥0.4 ms. Distal median motor latency, median motor compound muscle action potential (CMAP) amplitude, median mixed nerve latency and median and ulnar mixed interlatency differences were recorded for all patients.

2.3. US testing

Median nerve US images were obtained by neurologists trained in peripheral nerve US. Images were collected on the same day as EDx testing using an Esaote MyLab 70 equipped with an 18–6 MHz linear array transducer. The median nerve was imaged in cross section at the distal wrist crease (carpal tunnel inlet) and 12 cm proximal to this point in the forearm. The cross-sectional area (CSA) was calculated using the continuous trace method by outlining the perimeter just inside the hyperechoic epineurium. The CSA of any bifid nerve was calculated by adding the individual CSAs of the 2 components.

US findings were reviewed for median nerve CSA at the distal wrist crease and 12 cm proximal to the distal wrist crease. The wrist to forearm ratio (WFR) of CSA (wrist CSA/forearm CSA) was calculated. CSA >9 mm^2 and WFR >1.4 were used as cut-off values, based upon prior study.

2.4. Grading of CTS severity

CTS severity was graded based on two scales-EDX 3 (used at Duke EMG laboratory) and the internationally validated EDX 5 (Mhoon et al., 2012) . In the EDX 3 scale, severity is defined as no EDX evidence of CTS (0) if the median mixed and ulnar mixed nerve studies are normal, mild (1) if only the median mixed nerve action potential is abnormal or its latency is ≥0.4 ms longer than the ipsilateral ulnar mixed nerve action potential; moderate (2) if both the median mixed nerve conduction study and the median motor latency are abnormal or the median mixed nerve action potential is absent; and severe (3) if the median mixed nerve conduction study is abnormal and the median compound muscle potential amplitude and latency are abnormal. EDX 5 is as follows: Abnormalities of comparative (comparison of median nerve conduction through the carpal tunnel with the radial or ulnar nerve conduction in the same hand) and/or segmental studies (over a short conduction distance across the carpal tunnel) (1). Sensory nerve conduction velocity slowing in the digit-wrist segments (2), increase in distal motor latency (3), disappearance of the digit wrist sensory response (4), disappearance of motor response (5).

2.5. Statistical analysis

Statistical analysis was performed using JMP version 11 software (SAS, Inc., Cary, North Carolina). Pearson correlation coefficients were calculated to analyze the relationship between ultrasound findings and the clinical and EDx severity scales and clinical severity was analyzed in similar fashion. A correlation was considered clinically significant if $r > 0.4$ and $p < 0.05$ for a set of variables.

3. Results

3.1. Demographics/characteristics

The mean age of the 670 CTS patients was 56.6 ± 15 years. Mean BMI was 31.8 ± 8 in an area where 30% of all adults meet criteria for obesity (Ziswiler et al., 2005). The most commonly associated comorbidities were hypothyroidism (49.1%), followed by diabetes mellitus (41.9%). There were 233 (34.8%) men and 437 (65.2%) women examined. The majority of patients were right-handed (76.4%) and Caucasian (70.8%). These characteristics are described in Table 1. Differences between the three sub-groups (EDx abnormal/US normal, EDx and US normal and ED normal/US abnormal) are discussed in Table 2.

3.2. EDx/US findings

A total of 954 patients and 1,904 extremities had a diagnosis of CTS based on EDx studies.

Since not all physicians in the EMG laboratory are US trained, out of these 954 patients, 670 (70%) patients and 1,201 out of 1,904 extremities (53.8%) had both EDx and US studies done during CTS evaluation. Out of these 670 patients and 1,021 extremities,