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The ultrasonographic wrist-to-forearm median nerve area ratio in carpal tunnel syndrome

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Abstract

Objective: Peripheral nerve ultrasound is an emerging tool in the diagnosis of carpal tunnel syndrome (CTS). Although numerous publications have cited an increased median nerve area at the wrist to be the diagnostic of CTS, there has been considerable variability in the published normal values for this measurement. Our objective is to collect data on the wrist-to-forearm ratio (WFR) of median nerve area in patients with CTS and healthy controls.

Methods: Patients with electrodiagnostically proven CTS underwent ultrasonography of the median nerve at the wrist and forearm. The median nerve area was measured at these points and compared to values from asymptomatic volunteers.

Results: The WFR of median nerve area in asymptomatic volunteers was 1.0 ± 0.1. The WFR in patients presenting with CTS was 2.1 ± 0.5.

Conclusions: The WFR in patients with CTS is elevated as compared to asymptomatic controls. A WFR of $\geqslant 1.4$ gave 100% sensitivity for detecting patients with CTS while using only median nerve area at the wrist resulted in a sensitivity of 45–93%, depending on the cut-off value used.

Significance: The WFR of median nerve area promises to be a valid means of diagnosing CTS, and may be superior to measuring median nerve area at the wrist alone.

Keywords: Ultrasonography; Carpal tunnel syndrome

1. Introduction

Median neuropathy due to compression at the wrist, commonly known as carpal tunnel syndrome (CTS), is one of the most common indications for electrodiagnostic testing. A recent study performed in the United Kingdom revealed an incidence of CTS of 280.6 per 100,000 patient visits to general practitioners per year (Latinovic et al., 2006). As the population ages, and with obesity and diabetes mellitus becoming more prevalent, the incidence of CTS is likely to increase. Accurate diagnosis of CTS is important in guiding care and preventing possible disability and morbidity. Currently, electrophysiologic testing is generally considered to be the gold standard for the diagnosis of patients with a clinical presentation suggestive of CTS. Nerve conduction studies are highly specific (Jablecki et al., 2002) but may not be diagnostic in 10–25% of patients with clinical evidence of CTS depending on the severity of disease and the type of nerve conduction techniques used (Duncan et al., 1999; Jablecki et al., 2002; Preston, 2002). Newer techniques are reported to yield sensitivities near 98% but are not yet widely employed (Löscher et al., 2000).

Abbreviations: C, centigrade; cm, centimeters; CMAP, compound muscle action potential; CTS, carpal tunnel syndrome; MHz, megahertz; mm, millimeters; ms, milliseconds; SD, standard deviation; WFR, wrist-to-forearm ratio of median nerve area.

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Peripheral nerve ultrasonography is emerging as a promising diagnostic tool for entrapment neuropathies, particularly CTS. Several publications have specifically addressed measurement of median nerve area at the wrist as a means of diagnosing CTS (Buchberger et al., 1991; Hammer et al., 2006; Wong et al., 2004; Yesildag et al., 2004; Ziswiler et al., 2005). This is based on the premise that the median nerve is enlarged proximal to the site of compression in the carpal tunnel, which is supported by gross pathologic findings at the time of surgery (Tuncali et al., 2005). The nerve area is typically measured ultrasonographically by tracing the circumference of the median nerve in the proximal carpal tunnel at the level of the pisiform bone and calculating its area, although there is variability in the methods used among the published reports (Koyuncuoglu et al., 2005).

Normal limits for median nerve area have varied among reports, ranging from 7 to 9.4 mm^2 (Hammer et al., 2006; Walker, 2004; Werner et al., 2004); the values for diagnosing CTS range from 9 to 15 mm^2 (Beekman and Visser, 2003). Much of this variability is due to differences in measurement techniques, along with differences between populations studied.

Ultrasonography provides a simple, non-invasive means of visualizing peripheral nerve pathology, and its role in the diagnosis of CTS is promising. However, simple measurements of median nerve area at the wrist may not represent the optimal ultrasonographic parameter for diagnosis. For example, a patient with demyelinating hereditary sensorimotor neuropathy might have diffuse enlargement of all nerves (Martinoli et al., 2002). A single measurement at the wrist could result in a false positive ultrasound diagnosis of CTS. Given that recent data have shown normal median nerve area to be the same at the wrist and in the forearm (Cartwright et al., 2006),we hypothesize that a ratio of values at these sites may provide an alternative means of diagnosis. Given these findings, the ratio of median nerve area at the wrist as compared to the forearm (WFR) should approach 1:1. With median nerve enlargement at the wrist, as in CTS, a larger ratio is expected. This ratio should be less affected by the effects of variables such as weight and gender, as patients serve as their own controls. A ratio would also be less affected by differences in measurement technique.

The idea of using an ultrasonographic ratio as a diagnostic parameter for CTS is not entirely new, although our methods are. Keberle et al., 2000 calculated a "swelling ratio" between the median nerve area at the pisiform bone and distal radioulnar joint, and found it to be significantly different between 19 wrists in 10 controls and 15 CTS wrists in 8 patients. However, these sites are often technically difficult to image and prone to error, as described by the authors. By measuring at the distal wrist crease and a point 12 cm proximal in the forearm, easily reproducible sites not susceptible to significant imaging artifact were selected. In this study, we collected and compared preliminary data on the WFR of median nerve area in patients with electrodiagnostic evidence of CTS and healthy controls.

2. Methods

This prospective study compared patients seen in the Duke University Medical Center Electromyography Laboratory who had electrodiagnostic evidence of CTS to asymptomatic volunteers. Patients <18 years of age or having had a prior carpal tunnel release procedure were excluded. Women known to be pregnant were also excluded, as CTS during pregnancy may have a different etiology than CTS in other circumstances. The exclusion of pregnant women was not a factor in the study results, as none presented to the laboratory for diagnosis of CTS during the enrollment period. The study was performed in accordance with the standards of the Duke Institutional Review Board. All participating subjects signed informed consent.

Patients referred to the EMG laboratory with any signs or symptoms of CTS (e.g. pain or paresthesias in digits I–III, loss of sensation in the hand, weakness of grip, weakness or atrophy of the thenar eminence, wrist pain) underwent nerve conduction testing by neuromuscular fellows, neurology residents, or electrodiagnostic technicians on a Synergy electromyograph (Teca-Oxford Instruments, Pleasantville, New York). Bilateral median motor nerve responses and median/ulnar mixed nerve responses were performed with the hand warmed to a surface temperature of 34 °C. The median motor response was recorded over the thenar eminence, after stimulating the median nerve 6.5 cm proximally in the wrist. A distal latency of $\geqslant$4.4 ms was considered abnormal. Mixed nerve responses were obtained by stimulating the median and ulnar nerves in the palm and recording at the wrist, using a distance of 8 cm. Distal latencies of the median and ulnar mixed nerve responses should be approximately equal. An absolute median mixed nerve latency $\geqslant$2.2 or >0.3 ms longer than the ulnar mixed nerve latency is considered to be consistent with CTS. The sensitivity of the palmar mixed nerve method in detecting CTS in patients with symptoms of CTS is 74% (Simovic and Weinberg, 1999). If patients seen on days when the principal investigator was available to perform ultrasonography met any of the electrodiagnostic criteria for diagnosis of CTS, they were asked to participate in the study, and then underwent ultrasonography. These patients constituted the "CTS group". The ultrasonographer was blinded to nerve conduction study results, the indication for ultrasonography and final diagnosis, as both patients with and without electrodiagnostic or clinical evidence of CTS were referred for median nerve ultrasonography during the enrollment period. Other indications for median nerve ultrasonography were multifocal motor neuropathy, hereditary sensorimotor polyneuropathy, chronic inflammatory demyelinating polyradiculoneuropathy and