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Diagnostic value of high-frequency ultrasound in carpal tunnel syndrome during pregnancy: A case-control study

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Keywords
Carpal Tunnel Syndrome; Ultrasonography; Peripheral Nervous System Diseases; Pain; Median Nerve

Abstract

Background: Carpal tunnel syndrome (CTS) is the most prevalent entrapment syndrome in the upper limbs, for which pregnancy is a known risk factor. CTS diagnosis is confirmed via nerve conduction studies (NCSs), which sometimes is expensive, and the electrical stimulation makes it an unpleasant diagnostic modality, especially for pregnant subjects. Recently, high-frequency ultrasonography (HF-USG) is known as a diagnostic method. This study is concerned with determining the diagnostic value of this modality for CTS among pregnant women.

Methods: This cross-sectional case-control study was conducted with 40 CTS cases and 40 matched controls. The HF-USG of wrists was performed bilaterally on all participants with a focus on the median nerve cross-sectional area (MNCSA) at the carpal tunnel (CT) inlet.

Results: Mean MNCSA was statistically different between the CTS group (11.71 ± 1.86 mm^2, range: 8 to 18 mm^2) and the control group (6.75 ± 1.38 mm^2, range: 4 to 11 mm^2) ($P < 0.001$). The receiver operating characteristic (ROC) curve was drawn, and the cross-sectional area (CSA) cut-off point of 8.5 mm^2 showed sensitivity and specificity of 98% and 93%, respectively. The positive predictive value (PPV) and the negative predictive value (NPV) were 95% and 98%, respectively, with the mentioned point as the diagnostic threshold.

Conclusion: HF-USG of the median nerve can be utilized as a preferable alternative to NCS (the current gold standard diagnostic method) in pregnant women, due to its convenience and lower cost, or at least, it can be used as a screening tool among pregnant women with suspicious symptoms.

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Introduction

Carpal tunnel syndrome (CTS) is the most prevalent entrapment syndrome in the upper limbs, in which median nerve entrapment causes pain and paresthesia in the first three fingers and the radial side of the 4th finger.[1] CTS prevalence has been reported to be about 4% in the general population.[2] Known risk factors are obesity, diabetes, rheumatoid arthritis (RA),[3] and pregnancy.[4]

During pregnancy, it is most common in the 3rd trimester[5] and may cause bilateral symptoms.[3,4] According to a systematic review, CTS occurred in one-third to two-thirds of the pregnant population.[6] Although the main cause of higher prevalence in pregnancy is unclear, hormonal change which causes soft tissue edema may be one of the reasons.[4,7]

The diagnosis of CTS can be based on the history and physical examinations (including Tinel's and Phalen's tests) and can be confirmed by nerve conduction study (NCS), which has a 56%-85% sensitivity and a 94% specificity.[8] There were also some false negative[9] and false positive[10] results in CTS diagnosis by NCS. Moreover, diagnosis solely based on clinical findings has been reported to have moderate sensitivity and specificity.[11]

Recently, high-frequency ultrasonography (HF-USG) has been used as a diagnostic method for CTS,[12] since the nerve abnormality may be detected by an increased median nerve cross-sectional area (MNCSA).[13] As HF-USG can help determine the shape and size of the nerve and detect concurrent lesions, it can be useful in diagnosing CTS and distinguishing its differential diagnoses.[14]

NCS (the gold standard modality for CTS diagnosis) sometimes is expensive, and also painful electrical stimulation makes it an unpleasant diagnostic modality, especially for pregnant subjects. Since CTS has a high prevalence in pregnant populations, evaluating HF-USG as an alternative diagnostic method to NCS in pregnancy can be helpful.[13,15] Using the HF-USG, the anatomical structure of the median nerve can be investigated and possible concurrent pathologies might be identified. In addition, using this modality allows therapeutic interventions such as corticosteroid injections, minimizing the risk of median nerve damage.[16] In previous studies, the sensitivity and specificity of HF-USG and the gold standard, NCS, have been reported to be 82%-94% and 65%-97%, respectively.[17] In one study, the value of MNCSA ≥ 9.8 mm^2 had a sensitivity of 82% and a specificity of 87.5% in CTS diagnosis.[18] To our knowledge, until now, there have been few studies to evaluate HF-USG in pregnancy, yet with different methods. This study aims to determine the value of HF-USG in CTS diagnosis among pregnant women, as a preferable alternative.

Materials and Methods

This cross-sectional case-control study was conducted with 40 cases of CTS and 40 matched controls.

All participants were selected from the Prenatal Clinic of Firoozgar General Hospital, Tehran, Iran. Subsequently, they were referred to the Neurology Clinic at Firoozgar Hospital. Those who had both clinical symptoms of CTS and abnormal NCS findings were selected. NCS was also conducted on asymptomatic randomly-chosen pregnant women (the control group), to make sure that they were not patients with CTS. Additional data such as age, height, weight, body mass index (BMI), affected hand(s), history of miscarriage, parity, and current trimester of pregnancy were collected using questionnaires.

HF-USG of wrists was performed bilaterally on all participants, focusing on the MNCSA at the entrance of the carpal tunnel (CT).

The bilateral wrist US of included patients at the CT inlet was performed by a specialist (Dr. Mirzaasgari, MD and associate professor of neurology, who is an expert in neuro sonography, especially in peripheral nerve ultrasound) using MyLab™40-Esaote with an 18 MHz ultrasound probe to test the MNCSA.

The MNCSA at the CT inlet of the forearm was assessed blinded to clinical and NCS results. The participants sat facing the investigator with their arms in extended position, and their wrists flat on the table, their forearms in supine position, and their fingers in semi-extended position. The transverse US of the median nerve was conducted at the entrance of the CT. The pisiform bone was an anatomical landmark for testing the MNCSA at the CT inlet by drawing a straight line within the nerve hyperechogenicity boundary.

Based on the questionnaire's checklist, these individuals were excluded from both groups:

1- Those with a history of wrist surgery
2- Those with any history of injection in the wrist area
3- Those with a history of fracture in any of wrist bones
4- Those with a history of median nerve neuropathy or cervical radiculopathy or polyneuropathy

5- Those with an existing medical condition related to CTS, such as hypothyroidism, diabetes mellitus (DM), RA, renal failure, gout, tenosynovitis, wrist tumor or a ganglion cyst, amyloidosis, etc.

We used SPSS software (version 22, IBM Corporation, Armonk, NY) and Epi Info software for data analysis.

Results

During the study period (between 2017 to 2018), 40 cases and 40 controls were entered in the study, passing the inclusion/exclusion criteria. The average age in the case and control groups was 31.37 and 29.50 years, respectively. Most of these pregnant individuals were nulliparous and in their 3rd trimester of pregnancy. The demographic information of all participants is shown in table 1.

The average duration of CTS symptoms was 5.53 weeks in the case group. According to the symptoms, 78.8% of cases were in group 1 of the clinical classification of CTS, 18.8% in group 2, and 2.5% in group 3.[18] 65% of patients had experienced paresthesia, and 21.3% had experienced pain, daily. In addition, 95% of patients reported nocturnal wrist pain, 22.5% of patients complained of nocturnal paresthesia in the hand or wrist, and 5% had experienced weakness in the affected hand in the nighttime. According to our NCS results, 32.5% of cases were categorized as 'very mild', 38.8% as 'mild', 20% as 'moderate', and 8.8% as 'severe'.

- Result of median nerve measurement at the wrist: Interestingly, the median nerve HF-USG revealed the MNCSA to be 11.71 mm^2 [8-13 mm^2, standard deviation (SD) = 1.86] in the case group, in comparison to 6.75 mm^2 (4-11 mm^2, SD = 1.38) in the control group.
- An independent t-test showed a statistically significant difference between these two groups regarding median nerve diameter ($P < 0.001$) (Figure 1).

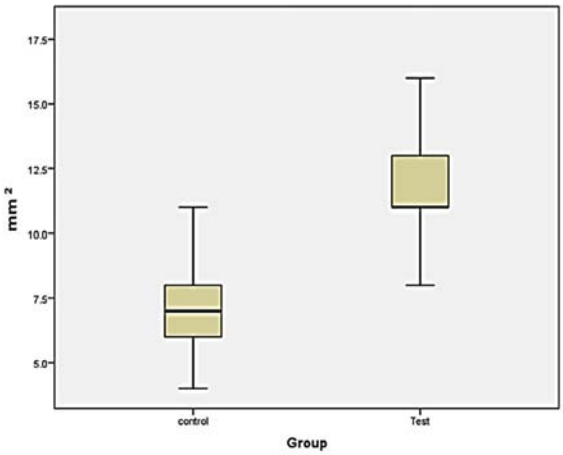

Figure 1. Median nerve cross-sectional area (MNCSA) in case and control group (a significant difference is seen between the case and control groups regarding MNCSA)

- The receiver operating characteristic (ROC) curve was drawn and at the cut-off point of 8.5 mm^2 for nerve cross-sectional area (CSA), a sensitivity of 98% and a specificity of 93% were calculated.
- The positive predictive value (PPV) was estimated to be 95%, and the negative predictive value (NPV) to be 98%. According to the ROC curve, the precision was 98% [95% confidence interval (CI): 0.97-1.00] (Figure 2).

Discussion

The gold standards for diagnosis of CTS are electromyography (EMG) and NCS, yet they may be expensive, time-consuming, and inconvenient for some patients.

These drawbacks, along with the fact that the prevalence of CTS is considerable in the pregnant population due to hormonal and physiological changes, make it a crucial task to find an alternative diagnostic method. HF-USG is more convenient, faster, and less expensive than NCSs.

Table 1. Demographic data of patients

Variable	Case group	Control group
Age (year) (mean ± SD)	31.37 ± 6.80	29.50 ± 2.22
BMI (kg/m^2) (mean ± SD)	27.73 ± 2.19	27.30 ± 2.22
Nulliparous individuals (%)	72.5	78.8
Individuals in the 1st trimester of pregnancy (%)	1.3	2.5
Individuals in the 2nd trimester of pregnancy (%)	16.3	21.3
Individuals in the 3rd trimester of pregnancy (%)	82.5	76.3

BMI: Body mass index; SD: Standard deviation

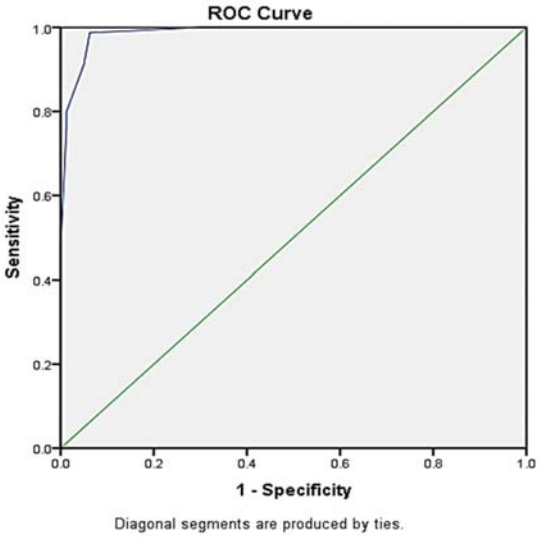

Figure 1. Receiver operating characteristic (ROC) curve of median nerve cross-sectional area (MNCSA) for carpal tunnel syndrome (CTS) [the cut-off point = 8.5 mm^2, sensitivity = 98%, specificity = 93%, precision = 98% with 95% confidence interval (CI): 0.97-1.00]

In this study, the value of HF-USG for diagnosing CTS in pregnant women has been evaluated, with a positive result. Considering the significant difference in US values (namely CSA) in patients and control groups, it seems that wrist HF-USG may be useful for CTS diagnosis during pregnancy. In other studies, the diagnostic value of EMG versus high-resolution sonography for CTS has been investigated. In one study, Visser et al. showed that the diagnostic value of sonography was similar to EMG, and it might be preferred in many patients due to its convenience and accessibility.[19]

In another study, Pastare et al. comparing the diagnostic value of high-resolution US with NCS in patients with clinically-defined CTS showed that NCS was more sensitive than the US (82% vs. 62%). But since the US had a PPV of 100%, it was concluded that it could be used as a screening test, decreasing the need for NCS in the majority of suspicious cases, and that NCS could be reserved for negative cases of US with a high clinical suspicion.[20]

Moreover, Mehrpour et al. investigated the diagnostic value of high-resolution US versus NCS in the subclinical cases of CTS with existing hypothyroidism. A CSA cut-off point of 9.8 mm^2 for the median nerve had 45% sensitivity and 95.8% specificity in diagnosis. The PPV and NPV of the US were 87.2% and 85.5%, respectively. They concluded that the US had an acceptable diagnostic value for confirmation of CTS in patients with hypothyroidism. However, in their opinion, the US had too low a sensitivity to replace NCS.[14]

Further, Salman et al. studied the diagnostic value of US in elderly patients. A CSA cut-off point of 8.5 mm^2 at the tunnel inlet, and the inlet-to-antecubital CSA ratio of 0.65 had the highest accuracy. These values had a sensitivity of 96.9% and 99% and a specificity of 93.6% and 28% for CSA at inlet and the CSA ratio, respectively. Thus, they concluded that the US had excellent sensitivity and specificity for the diagnosis of CTS in elderly patients.[21]

Another study by Azami et al. revealed that a threshold of 9.15 mm^2 for CSA at the tunnel inlet had the best diagnostic value with 99.2% sensitivity and 88.3% specificity. Besides, MNCSA values in clinically mild, moderate, and severe categorized cases of CTS were significantly different.[22]

The diagnostic value of US in patients with electrophysiologically confirmed CTS has been evaluated by Ashraf et al. Their study revealed that the cut-off point of 9.3 mm^2 for MNCSA had 80% sensitivity and 77.5% specificity in CTS diagnosis.[23] Mohammadi et al. showed the sensitivity and specificity of CSA cut-off of 8.5 mm^2 to be 80% and 77.5%, respectively.[24]

In our study, the cut-off point for MNCSA had a sensitivity and specificity of 98% and 93%, respectively, in the diagnosis of CTS. The PPV and NPV were 95% and 98%, respectively. The discrepancy in results of different studies might be due to differences in operators' abilities and US devices, different sample sizes, variation in the duration of symptoms, or other potential factors.

All of these studies showed the diagnostic value of the US to be great and promising. However, some studies have demonstrated a low sensitivity for US measures in the diagnosis of CTS.

Conclusion

According to our findings, wrist HF-USG in pregnant women for evaluating the median nerve, can be used as an alternative method in CTS diagnosis. Considering the advantages of this method, including availability, low cost, and convenience, over the gold standard diagnostic method of NCS, it might be a more preferable modality, at least as a screening tool for pregnant individuals with suspicious symptoms of CTS.

Limitations: Since this study was the first of its kind, we could not compare our findings with

other studies' results performed on pregnant populations with CTS symptoms. More studies should be carried out to achieve a more accurate and reliable cut-off of CSA for CTS diagnosis by sonography in pregnant women.

Conflict of Interests

The authors declare no conflict of interest in this study.

Acknowledgments

Our study was performed according to the Declaration of Helsinki. Participants were informed of the study and the written consent was obtained before enrollment in the study. This study was approved by the Ethics Committee of Iran University of Medical Sciences, Tehran (code: IR.IUMS.REC 1396.8821215184).

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