COMPARISON BETWEEN ULTRASONOGRAPHY AND ELECTRO-DIAGNOSTIC STUDIES IN DIAGNOSTIC ACCURACY OF CARPAL TUNNEL SYNDROME AMONG A SAMPLE OF EGYPTIAN POPULATION

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ABSTRACT:

Purpose: To compare diagnostic accuracy between ultrasonography and Electro-diagnostic studies in diagnosis of carpal tunnel syndrome among a sample of Egyptian Population

Materials and Methods: Thirty patients clinically diagnosed as carpal tunnel syndrome in neurosurgery, orthopedic surgery departments and outpatient clinics. Nerve conduction tests; 1) Digit to wrist sensory conduction studies of the median and ulnar nerves, 2) palm to wrist mixed nerve conduction studies (comparing motor and sensory conduction velocities between the median and ulnar nerves). Diagnosis of CTS was made if median nerve sensory conduction velocity (SNCV) was less than 39m/sec while the ulnar SNCV was normal. Median distal motor latency (DML) more than 4.3 msec and /or conduction velocity difference between median and ulnar nerves is more than 10m/sec. Cross sectional areas in cm^2 (CSA) of the median nerves was determined using real time ultrasonography, while flattening ratio (FR) was calculated using the ratio of the medio-lateral diameter to the anterior posterior diameter on cross section, At each level three measurements of CSA and FR were taken and averaged. In addition the volume of the affected segment was also qualitatively assessed. For comparison, normal controls with no history of hand symptoms, previous hand injury or surgery to the wrist were also studied. Statistical analysis using ANOVA and student's t tests were used to compare mean CSA and FR between CTS hands and controls

Results: Median nerve CSA and volume were significantly larger in CTS hands compared to controls. Sensitivity scores (FSS) correlated with FR at tunnel outlet (p=0.040) but not with other ultrasound parameters or with NCS. CSA at the tunnel inlet correlated with median DML (p=0.004)

Conclusion: Ultrasonography is a useful diagnostic tool for CTS and median nerve abnormality, it is also useful in qualitative appearance of the median nerve which is an important adjunctive findings in CTS

KEY WORDS:

Electro-diagnostic
Carpal tunnel
Nurosurgery
Ultrasonography

INTRODUCTION:

Discomfort of the hand and wrist is caused by a wide variety of diseases including entrapments of the nerves (such as carpal tunnel syndrome, entrapment of the ulnar nerve, and cervical radiculopathy), tendon disorders, overuse of muscles, nonspecific pain syndromes, and less common disorders. The prevalence of symptomatic carpal tunnel syndrome is about 3 percent among women and 2 percent among men, with peak prevalence in women older than 55 years old.[1]

Carpal tunnel is located at the base of the palm, just distal to the distal wrist crease. It is bounded on three sides by the carpal bones, which create an arch, and on the palmar side by the fibrous flexor retinaculum, or transverse carpal ligament. Nine flexor tendons (two extending to each finger and one to the thumb) traverse the carpal tunnel, along with the median nerve.

Elevated pressure in the carpal tunnel produces ischemia of the median nerve, resulting in impaired nerve conduction with resulting paresthesia and pain. Early in the course, no morphologic changes are observable in the median nerve, neurologic findings are reversible, and symptoms are intermittent. Prolonged elevated pressure in the carpal tunnel may result in demyelination and more severe symptoms, occasionally with weakness. When there is prolonged ischemia, axonal injury ensues, and paralysis may be the end result.[2,3]

Conditions may be associated with carpal tunnel syndromeincludes pregnancy, inflammatory arthritis, Colles' fracture, amyloidosis, hypothyroidism, diabetes mellitus, acromegaly, and use of corticosteroids and estrogens[4,5] about 6 percent of patients have diabetes.[5] Carpal tunnel syndrome is also associated with repetitive activities of the hand and wrist, particularly with a combination of forceful and repetitive activities.8-10 Occupations include food processing, manufacturing, logging, and construction work . [6,7]

Carpal tunnel syndrome is usually diagnosed clinically by certain clinical tests and confirmed by a combination of electro-diagnosticstudies (nerve-conduction studies and electromyography). Information about the location and type of symptoms allows the most accurate diagnosis of carpal tunnel syndrome.[8] Symptoms occur in up to 15 percent of the population,false negativeand false positiveresults on electro-diagnostic testing have been is documented.[8,9,10]

Hence, ultrasonography has emerged as an important diagnostic investigation for CTS, a variety of ultrasonographic changes have been demonstrated in CTS including swelling and flattening of the median nerve, palmar bowing an thickening of the flexor retinaculum and changes in median nerve appearance. The most common described abnormality has been enlargement of median nerve cross sectional area (CSA) usually proximal to the carpal tunnel.

The diagnostic accuracy of ultrasonography compared to the NCS have been variable, therefore the role of ultrasonography in CTS remain to be defined.

Rational of the work:

The aim of this study is to determine ultrasonographic criteria for the diagnosis of CTS and to compare its diagnostic accuracy with NCS

PATIENTS AND METHODS:

Patients clinically diagnosed with CTS over 6months duration in neurosurgery, orthopedic surgery departments and outpatient clinics at El Minia university hospital. American Association of neuromuscular and electro diagnostic medicine (AANEM) clinical diagnostic criteria was our reference in this study. All patients underwent NCSelectromyography. Nerve conduction tests; 1) Digit to wrist sensory conduction studies of the median and ulnar nerves, 2) palm to wrist mixed nerve conduction studies (comparing motor and sensory conduction velocities between the median and ulnar nerves).

Diagnosis of CTS was made if median nerve sensory conduction velocity (SNCV) was less than 39m/sec while the ulnar SNCV was normal. Median distal motor latency (DML) more than 4.3msec and /or conduction velocity difference between median and ulnarnervesis more than 10m/sec

CTS is classified as; 1) Mild (abnormal median SNCV with normal median DML). 2) Moderate (abnormal median SNSV and prolonged DML) or 3) Sever (absent median sensory response).

Ultrasonography of the carpal tunnel in this study was carried out by a single radiologist who is skilled in the musculoskeletal ultrasonography. Toshiba Nemio XG machine with a linear 7.5 MHz probe was used, cross sectional ultrasound was carried out for every patient wrists at three levels; 1) Proximal to the carpal tunnel inlet (proximal to lunate); 2) Carpal tunnel inlet (correspond to scaphoid tubercle); 3) Tunnel outlet (Just beyond the scaphoid).

Cross sectional areas in cm2 (CSA) of the median nerves was determined using real time ultrasonography, while flattening ratio (FR) was calculated using the ratio of the medio-lateral diameter to the ant. Posterior diameter on cross section, At each level three measurements of CSA and FR were taken and averaged. In addition the volume of the affected segment was also qualitatively assessed. Ultrasound technique was carried out by a linear transducer shifted from the distal radius to beyond the scaphoid along the radial aspect of the wrist with no changes in the transverse position to reach the hamate.

For comparison, normal controls with no history of hand symptoms, previous hand injury or surgery to the wrist were also studied.

Statistical analysis using ANOVA and student's t tests were used to compare mean CSA and FR between CTS hands and controls

RESULTS:

Thirty patients were included in our study of which 20 (66.6%) were women, with a mean age were 50.4 years, 43hands were diagnosed to have CTS based on clinical suspicion. All patients underwent both NCS andreal-time ultrasonography. In addition, 43 normal hands from 30 healthy controls were also studied by ultrasound.

Findings from ultrasound images are collected ***(***table 1), median nerve CSA and volume were significantly larger in CTS hands compared to controls, at all three levels described above, there was also a significant difference in the FR at the tunnel inlet but not much affected at the levels proximal to the inlet and the tunnel outlet, Evident finding in CTS patient at time of maximum mani-festations with evident symptoms of nerve compression, marked increase in nerve volume at the carpal tunnel was noted by ultrasound compared to the nerve proximal to the tunnel and at its outlet. ROS curves were used determine values for CSA at all three levels and FR at the tunnel inlet. CSA proximal to the tunnel inlet with a threshold of 0.10 cm^2 give the best diagnostic accuracy with sensitivity and specificity of 73% and 82% respectively, followed by CSA at the tunnel inlet with a threshold of 0.10cm^2 which give a sensitivity and specificity of 35.0% and 86% respectively. CSA at the tunnel outlet which a threshold of 0.09cm^2 yielded a sensitivity of 65.5% but a lower specificity of 74%. FR of 2.65 at the tunnel inlet gave a sensitivity of 69.5% but a lower specificity only 51.6%. If CSA at either of 2 levels compared to proximal to or at the tunnel inlet where considered together the resulting sensitivity and specificity increased to 80.5% and 81.2% respectively (table 2).

Sensitivity scores (FSS) correlated with FR at tunnel outlet (p=0.040) but not with other ultrasound parameters or with NCS. CSA at the tunnel inlet correlated with median DML (p=0.004)

Table 1: Mean ultrasound measurements of cross sectional area at different levels of median nerve at both carpal tunnel syndrome patients and controls (CSA, cross sectional area. FR: flattening ratio of median nerve* statistically significant (P<0.05)

Ultrasound measurements	CTS hands	Control	P value
Mean CSA proximal.	0.121	0.077	P<0.0001
Mean CSA at tunnel inlet	0.125	0.079	P<0.0003
Mean CSA at tunnel outlet	0.109	0.076	P<0.0002
Mean FR proximal tunnel inlet	3.164	3.388	P=0.1342
Mean FR at tunnel inlet	3.122	2.750	P=0.0219
Mean FR at tunnel outlet	2.995	2.581	P=0.4232

Table 2: sensitivity and specificity of ultrasound for carpal tunnel syndrome using median nerve cross sectional area (CSA), at the carpal tunnel inlet and outlet.

	CTS group	Controls	P value
CSA proximal to tunnel >0.1cm^3 or CSA at tunnel inlet >0.1 cm^2	43	10	P<0.0001
CSA less than or equal to 0.1cm^2 at a level proximal to tunnel and at tunnel inlet	9	41	
	Sensitivity 80.5%	Specificity 81.2 %	

Table 3: Sensitivity and specificity of qualitative features of the nerve in determining carpal tunnel syndrome

Nerve appearance on cross section proximal to inlet	CTS group	Controls	P value
Normal homogenous echogenicity	11	41	P<0.0001
Heterogeneous echogenicity	43	4	
	Sensitivity 76.8%	Specificity 95.2%	

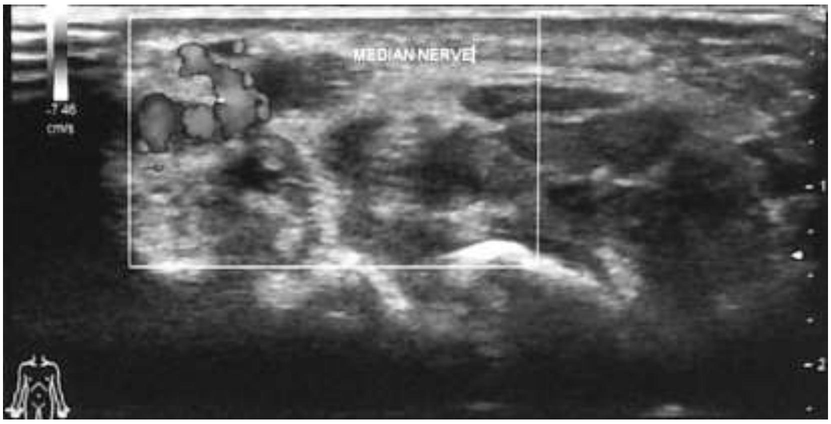

Figure 1a: Normal control shows median nerve with heterogonous echogenicity with speckled linear hyperechoic and hypoechoic appearance of median nerve. Normal measurement is taken to be 0.1cm2 or less in cross sectional area

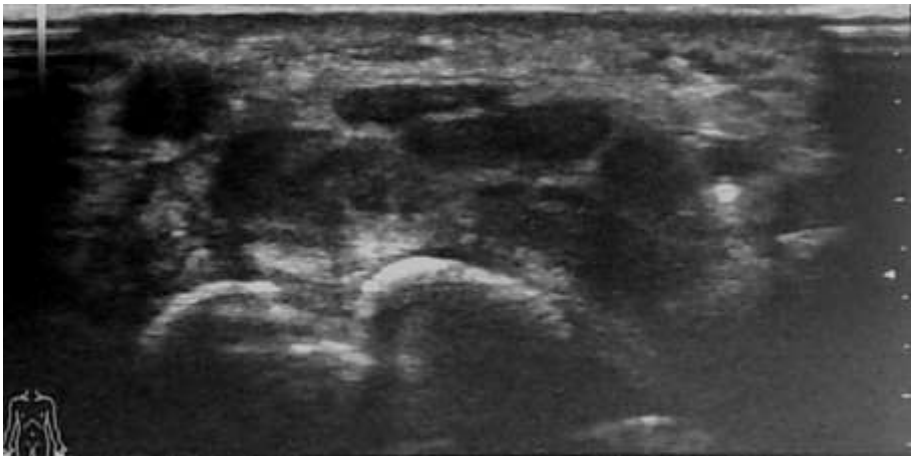

Figure 1b: Carpal tunnel syndrome patient shows median nerve with loss of the hyperechoic linear appearance (loss of fascicular discrimination) at the level of tunnel inlet (qualitative assessment). The area of median nerve is 11mm2 which is significant more increase means more manifestations

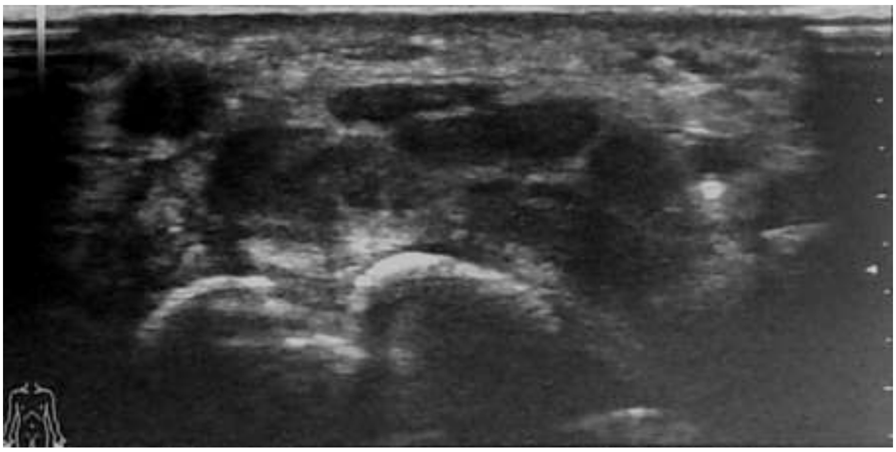

Figure 2: Carpal tunnel syndrome patient shows median nerve with loss of heterogonous speckled linear appearance with markedly flattened and increased volume.

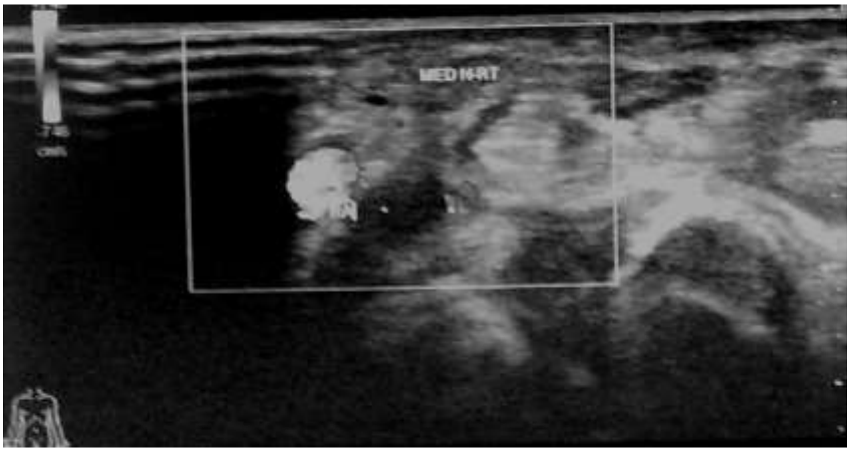

Figure 3: Neglected carpal tunnel syndrome patient showing echogenic median nerve with markedly reduced volume compared to controls and manifest patents

DISCUSSION:

Results tabled above are consistent with previous studies of ultrasound in CTS in showing increased diameter and volume of median nerve in CTS hands[11-12]. There was significant clear difference in median nerve CSA between control and CTS patientsmeasured proximal to the tunnel inlet, at the inlet and outlet as well as in the FR at the tunnel inlet. In literature CSA threshold values for different levels of the carpal tunnel have ranged from 0.09 cm^2 to 0.15 cm^2 with varying sensitivities and specificities ranging from 70% to 88% and 63 % to 97% respectively[13-16], however in the diagnosis of CTS in our population, ROC curves estimated the optimal CSA thresholds to be 0.1cm^2 proximal to and at the inlet and 0.09cm^2 at the tunnel outlet and 2.65 for the FR at the tunnel inlet with highest sensitivities and specificities found for median nerve CSA proximal to the tunnel inlet .

The sensitivity of ultrasonography may increase if more than one parameter is combined in the diagnostic criteria. In our study combined CSA criteria at either of 2 levels (proximal to or at the tunnel inlet) resulted a higher sensitivity and specificity than if they were considered alone. One study used the mean carpal nerve area (average of CSA of all three levels) and improved its diagnostic sensitivity from 43% to 67%.In another study a CSA of 0.11 cm^2 proximal to the tunnel resulted a high specificity (98%) but had also high numbers of false negatives (26.4%).[15]

Qualitative appearance of the median nerve is useful ultrasonographic parameter several studieshave commented on the loss of fascicular decrimentation in the median nerve.[14,15,18] other qualitative features reported included compressed appearance of the nerve on longitudinal view and the presence of intratunnel hyper vascularization using color Doppler ultrasound,[19] in this study a hazy homogenous appearance with loss of vascular discrimination in the compressed nerve at the level proximal to the tunnel inlet at relatively high sensitivity and specificity of 76.8% and 95.2% respectively however qualitative assessment of the nerve is subjectively and as such cannot be used as a standalone criterion for CTS, but as complementary to conductive measurements. However NCS is not always abnormal in CTS and in two studies ultrasonography revealed abnormal findings in CTS patients who had normal NCS.

Ultrasonography appear to be relatively quiet specific for CTS,[15,16] furthermore ultrasonography may be useful in sever CTS, where NCS may be un recordable, there was correlation between median nerve CSA at the tunnel inlet and median DML. As prolonged median DML is a marker of focal nerve myelination across the carpal tunnel, this provides a biological bases for the ultrasonographic findings in CTS, however median nerve CSA on the wall did not correlate well with symptoms severity and functional severity scores

Limitations recorded in this study; 1) Ultra-sonographer was not blinded to the diagnosis of CTS although he was blinded to the NCS results, raising the possibility of observe base; 2) The recruitments of patients was from CTS cases seen consecutively at the clinic while recruitments of normal control was based on their willingness to participate in the study, this resulted in younger mean age for controls; 3) we did not take additional biophysical measurements for example height, weight or wrist size/ circumference, as recent study has shown the median nerve CSA to correlate significantly with wrist circumference and that this has to be taken into account when determining CSA cut off values.[20]

The role of ultrasonography vis-a vis NCS remains unclear, compared to NCS, its sensitivity is less, although it is quite specific. In view of its relatively non invasive way, high specifically, some have suggested that ultrasonography be used as screening test for CTS before performing NCS.[16]. The radiologist has also introduced in this paper a simple method to locate the proximal tunnel and tunnel inlet based on the lunate "raising sun appearance" and the location of the scaphoid tubercle, unlike NCS it can only demonstrate median nerve lesion/ compression and not investigate for other causes of upper paraesthesia[17]. However it can show more morphology of the median nerve and demonstrate other pathology e.gsynovitis which can contribute to the development of CTS, another diagnostic imaging modality that has been shown to be useful in CTS is MRI,[21] but the ease and comparative lower cost of ultrasonography will make it a better choice.

CONCLUSION:

In conclusion this study support previous studies in proving the usefulness of ultrasonography in diagnosing CTS, the main median nerve abnormality and enlargement of the median nerve proximal to and at the inlet, although we also found increased in volume of the compressed nerve and qualitative appearance of the median nerve on ultrasonography is an important adjunctive findings in CTS.

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