The effects of cold stress on Nerve Conduction Study parameters of Normal hands and hands with carpal tunnel syndrome

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تأثيرات إجهاد ألبروده على قياسات تخطيط الأعصاب والعضلات الكهربي للأيادي السليمة والأيادي ألمصابه بمتلازمة نفق الرسغ

الخلاصه

إن متلازمة نفق الرسغ تسبب الم و خدر اليد، وتعطل الإعمال اليدوية، يصيب النساء. غالبا" لا يوجد سبب محدد، بل تصاحبه عدة حالات تستدعي الدراسة، كتقصي جريان الدم، فنقصان ألترويه ألدمويه تشارك مع انضغاط العصب الوسطي في إحداث متلازمة نفق الرسغ.

الأشخاص في هذه الدراسة، اجري لهم بعد الفحص ألسريري تخطيط الأعصاب الأولي، ثم اجري تخطيط الأعصاب الثاني ولكن تحت إجهاد البرودة بعد تبريد اليدين فأظهر تغيرات ملحوظة بشكل مميز (قيمه ألاحتماليه اقل من 0.001) في كفاءة العصب الوسطي خاصة بالأيادي المصابة مقارنه مع الأيادي السليمة، وكمقارنه ما قبل و ما بعد إجهاد البرودة على كفاءة العصب تم تسجيل طول في الكمون و بطء في التوصيل الحسي والحركي بالأيادي المصابة بشكل مؤثر غير قابل للصدفة (قيمه ألاحتماليه اقل من 0.001) فالأيادي المصابة بمتلازمة نفق الرسغ تأثرت بالبرودة أكثر من الأيادي السليمة (بمقدار احتماليه اقل من 0.006) في الكمون و (قيمه ألاحتماليه اقل من 0.04) في بطء التوصيل الحسي والحركي للعصب الوسطي.

ABSTRACT

Carpal tunnel syndrome (CTS) is a significant cause of hand paresthesia and responsible for loss of jobs, attack the women more. Recent Investigations evaluated the blood flow and emphasized the vascular cause of CTS in addition to median nerve compression.

For all the study sample had been done after physical examination, a first Nerve Conduction Study (NCS), then further second NCS which carried out under Cold stress test with cooling the hands, showed significant high latencies ($p<0.001$) and low velocities ($p<0.001$) of motor and sensory median nerve in cooled CTS hands as compare to cooled Normal hands consequently the cold stress test is worst and positive with CTS hands, therefore the cold stress can induce detectable variations in NCS parameters of CTS hands, which was calculated significantly higher motor and sensory latencies ($p<0.006$) and lower velocities ($p<0.04$) than that before cold stress, whereas in Normal hands no significant differences after cold stress.

1:Introduction

This study is concerning the Carpal tunnel syndrome (CTS), which has become a significant public health problem, a common peripheral entrapment neuropathy, and recognized as one of the most important causes of pain and functional impairment of the hand and workplace morbidity (1; 2).

Phalen definition (1981) of Carpal Tunnel Syndrome required patients to have one or more of the three bedside findings: Sensory changes restricted to the median nerve distribution of the hand, Positive Phalen sign, and Positive Tinel sign .

Though electrodiagnosis was not part of Phalen's definition, clinicians now use NCS frequently to confirm the diagnosis.

NCS remain the criterion standard for diagnosis of CTS which is a common neuropathy often diagnosed with the aid of NCS, Golden standard for the diagnosis is usually based on a combination of clinical assessment and nerve conduction studies (3).

The CTS remains vague to physicians when it needs a decision in respect of non-surgical or surgical treatments (4; 5).

However, both clinical evaluation and electrophysiological assessment have their own limitations, the clinical signs are moderately sensitive and specific, and the routine Nerve Conduction Study (NCS) may miss the diagnosis of CTS in up to 15-25% of cases (6; 7), the false-negative and false-positive results of NCS have been reported (8).

In this study when the results of clinical examinations or NCS are inconclusive, the NCS carried out before and after cooling the hands to detect the effects of cold stress on nerve conduction parameters to evaluated the blood flow in the CTS hand and emphasized the vascular mechanism (9; 10; 11)., which will evidently distorted in CTS hands rather than Normal hands.

2: Patients and Methods

2.1:Study Sample subjects

Complaining subjects in our study had been referred to electroneurography test with suspicion of CTS, they selected randomly and examined in Middle Euphrates Neurosciences centre, of AL- Sader Medical City in AL- Najaf, between August 2010 and February 2011, the apparatus that was used (Micro-Med) Italian made, model 2001

for 80 cooperative subjects a physical examination, first nerve conduction study, then under cold stress a second nerve conduction study had been done.

No patients were pregnant, breast feeder, smoker, and alcoholic , or had any underlying systemic diseases such as diabetes, hypertension, thyroid dysfunctions, anemia, and uremia or a blood dyscrasia, Raynaud's disease, and rheumatoid arthritis. Patients with wrist arthropathy, trauma of the median nerve or cervical radiculopathy were also excluded.

For identification of the abnormalities from the disease group, a normal persons were considered as controls, after confirmation the clinical absence of CTS, their age (mean ± SD) was 32 ± 8 years, matched the CTS patients age 38 ± 10 years (mean ± SD).

2.1.1: The clinical assessment of CTS was based on:

i: Classic CTS symptoms: hand paraesthesiae in the median nerve distribution zone (12), and night rouse with pain, heavy hand and parasthesia (13) therefore the patient to get relief, shaking his hands as that resembles shaking a thermometer : flick sign (14).

ii: Specific physical examination: accepted tests to be positive are: thenar muscle weakness or atrophy, *and two provocation tests*:

Phalen test (15), and Tinel test (16).

2.1.2: Nerve conduction study (NCS):

population-based evaluations of diagnostic NCS are often hampered by the absence of a reliable standard reference values with which to assess accuracy of CTS diagnosis (17). The requirement, stated in the practice parameter, that each neurophysiological

laboratory should have its own reference values (3) for example the distal motor latency the cutoff values used in different studies have ranged from 3.8 ms to 4.6 ms (18) , and in other studies**:**

The Normal range of Median Nerve conduction study:

*Stimulation site at 3 cm proximal to distal wrist crease and recorded from index finger ≈ 12 cm

Antidromic [direction opposite to physiologic conduction]

Sensory latency **(SL) = 2.84 ± 0.66 m.s (upper limit = 3.5)**

velocity **(SCV) = 56.2 ± 12.2 m/s (lower limit = 44)**

* Stimulation site at 3 cm proximal to distal wrist crease and recorded at palm ≈ 6 cm with surface electrodes over the Abd. pollicis brevis muscle

Motor latency **(ML) = 3.49 ± 0.71 m.s (upper limit = 4.2)**

Velocity (MCV) = 48.8 ± 10.8 m/s (lower limit = 38)

***** Stimulation site at **E**lbow

Velocity (MCV) = 57.7 ± 9.7 m/s (lower limit = 48)

(19; 20)

Whereas the normal value in Middle Euphrates Neurosciences center among control studies (which had been matching with other national labs.) was the same, a part of sensory conduction velocities from ring electrodes on the index finger, to stimulation site in the wrist at 12 cm distance, was different in lower limit which was 40 m/sec.

2.2:Methods

2.2.1: Nerve conduction study (NCS):

-Antidromic sensory NCS of Median nerve are recorded from a median innervated digit, typically by placing ring electrodes on the index finger, with electrical stimulation at the wrist.

-Antidromic sensory NCS of the ulnar nerve is recorded with ring electrodes on little finger and at 12 cm distance stimulation in the wrist on the ulnar aspect(19; 21).

-The median motor response is recorded with surface electrodes over the Abductor pollicis brevis muscle (APB) and stimulation at the wrist and elbow.

- The ulnar motor response is recorded with surface electrodes over the hypothenar muscle and stimulation at the wrist and elbow.

- A second Median motor and sensory nerve conduction study carried out in same procedure but after cooling the hands, as NCS under cold stress test to study the effects of coldness on NCS parameters.

2.2.2: The electrophysiological diagnosis of the CTS

was based on two, or more, of the following

i. Prolonged distal motor latency: a distal motor latency of the median nerve longer than 4.2 ms at 6 cm distance from the stimulation site on the flexor aspect of the wrist to the APB muscle was categorized as abnormal (19).

ii. Slowed sensory nerve conduction velocity (SNCV) from the index digit to the wrist, segment of the median nerve: a SNCV measured over the neural segment of the median nerve from the index digit to the wrist of less than 40 m/s at a 12 cm distance, was categorized as abnormal (22).

iii. Reduced amplitude of compound muscle action potential (CMAP) or sensory nerve action potential (SNAP) in the nerve conduction study: a peak to peak CMAP smaller than 5 mV, or SNAP smaller than 10 μV, were categorized as abnormal (23).

iv. Presence of retrograde degeneration: retrograde degeneration was defined as when the mixed nerve conduction velocity was slower than 45 m/s in the forearm segment of the median nerve (24).

v. Median versus ulnar nerve (antidromic) distal sensory latencies are recorded on the ring finger, with stimulation at 12 cm, same distance in the wrist. A differences of 1 ms or greater is abnormal, measurement of median-ulnar sensory latency difference appears to have the highest diagnostic accuracy(25; 26).

2.3: Cold Stress Test

The patient put on disposable lightly powdered gloves in both hands, then both hands are immersing in cold water box at safe and tolerable chosen degree as 12 °C sustained coldness, and pulling out after one minute calculated by special sport watch, the hands putting down word vertically above the water, to prevent wetness of the arm, we have remove the gloves, a second median nerve conduction study done under cold stress test to study cold effect on NCS parameters.

3:The Results

A second NCS under cold stress were made for 60 hands of 30 normal subjects plus 100 hands of 50 patients with CTS.

3.1: The changes in Nerve Conduction Study parameters Before and After Cold stress among Normal and CTS hands.

The cold stress and low temperature can induce detectable variations in NCS motor and sensory parameters, which calculated in CTS was significantly higher ($p<0.006$) latencies and significantly lower ($p<0.04$) velocities than that before cold stress.

Table 16:The effect of cold stress on NCS parameters among CTS and Normal hands groups before and after the test.

NCS Parameters		Before cold	After cold	Difference	P
60 *Normal Hands*					
Motor	**Latency**	**3.44 ± 0.44**	**3.86 ± 0.44**	**0.4 ± 0.29**	**<0.02**
	Velocity	**55.6 ± 5.54**	**54.7 ± 4.9**	**2.23 ±2.2**	**>0.6 N.S**
Sensory	**Latency**	**2.5 ± 0.39**	**2.72 ± 0.39**	**0.23 ± 0.1**	**>0.2 N.S**
	Velocity	**48.3 ± 5.7**	**45.9 ± 5.7**	**2.52 ±1.36**	**>0.2 N.S**
100 *CTS Hands*					
Motor	**Latency**	**4.75 ± 0.6**	**5.35 ± 0.76**	**0.54 ± 0.3**	**<0.006**
	Velocity	**55.1 ± 5.9**	**51.62±5.95**	**4.24 ±3.4**	**<0.04**
Sensory	**Latency**	**3.54 ± 0.42**	**3.93 ± 0.44**	**0.39 ± 0.1**	**<0.003**
	Velocity	**33.8 ± 3.67**	**30.18±4.18**	**3.9 ± 2.2**	**<0.002**

All values are given as mean ±SD P value: using paired two tail t-test.
The Latency in m. second The Velocity in m/second

3.2: The comparison between Normal and CTS hands according to variation of Nerve Conduction Study parameters under Cold stress. The NCS diagnostic principles of CTS be dependent on the variation with Normal motor and sensory nerve conduction study parameters, this variation will be, significantly higher latency and lower Velocity after cold stress.

Table 15: The comparison between Normal hands and CTS hands groups before and after cold stress regarding NCS parameters.

NCS Parameters		Normal (60 hands)	CTS (100 hands)	P
			Before cold	
Motor	**Latency**	**3.44 ± 0.44**	**4.75 ± 0.6**	**<0.001**
	Velocity	**55.6 ± 5.54**	**55.15 ± 5.9**	**>0.7(N.S)**
Sensory	**Latency**	**2.5 ± 0.39**	**3.54± 0.42**	**<0.001**
	Velocity	**48.35 ± 5.7**	**33.8 ± 3.67**	**<0.001**
			After cold	
Motor	**Latency**	**3.86 ± 0.44**	**5.35 ± 0.76**	**<0.001**
	Velocity	**54.7 ± 4.9**	**51.62 ± 5.95**	**<0.05***
Sensory	**Latency**	**2.72 ± 0.39**	**3.93 ± 0.44**	**<0.001**
	Velocity	**45.9 ± 5.7**	**30.18 ± 4.18**	**<0.001**

All values are given as mean ±SD
*P value: using paired two tail t-test, except * one t -tail*
The Latency in ms, Velocity in m/s

4: Discussion

4.1:- The changes in Nerve Conduction Study parameters Before and After Cold stress among Normal and CTS hands.

The cold stress and low temperature can induce detectable variations in NCS parameters, that was calculated in CTS as significantly higher motor and sensory latencies ($p<0.006$) and significantly lower velocities ($p<0.04$) than that before cold stress, thus in Normal group no significant differences after cold stress, except for motor latency, which was significantly higher (but stays within normal hand parameters range), this was mostly due to that mixed Normal group results which included normal hands together with NWC and cold hands parameters.

The temperature has dramatic effect on nerve conduction study parameters, however, these are based on normal nerves in normal individuals and may not be appropriate in the diseased nerve setting, but in carpal tunnel syndrome, the median nerve reacts differently to temperature changes compared with normal ulnar controls. Furthermore,

statistically significant differences exist between the rates of change with increasing temperature in motor and sensory nerves(27).

4.2:- The comparison between Normal and CTS hands according to variation of NCS parameters under cold stress test.

The NCS diagnostic principles of CTS against normal hand are prolong latency and slow velocity of motor and sensory median nerve study, as appear in the first NCS done before cold stress test, in this clinical study, a second NCS carried out after cooling the hand under cold stress test to evaluate this effect on NCS parameters, showed significant high latencies ($p<0.001$) and low velocities ($p<0.001$) of motor and sensory median nerve in cooled CTS hands as compare to cooled Normal hands consequently the cold stress test is worst and positive with CTS hands, whereas the motor velocity showed less significant difference ($p <0.05$ one tail t-test) because the cooling process restricted to the hand only and not exceeded to forearm accordingly in this region the median nerve segment was out of cold stress effects.

Sympathetic median nerve fibers in the CTS are hyperirritable producing a changes during cold stress and clinical observations have suggested the presence of vasomotor changes (28).

Clinical experience shows that the CTS symptoms worsen in cold weather and lessen in warm weather although the severity of the disease does not change (29).

Conclusions

The positive Cold stress test, shows that CTS is a neuro-vascular disorder when the vascular disturbance is associating with Median neuropathy, since the Median nerve carries most of hand's sympathetic fibers, whilst the vascular changes induced nerve ischemia, so both can represent the sign and symptoms of CTS, as the incitation or as the amercement.

Shortcoming

The results of this study may have been affected by a number of limitations as skin thickness, body fat, invisible tissue artifacts, and other physiological biases could have incorrect results.

In this study test the electricity was near the water, together, alarmed the patients.

Suggestion

Enhancement of hand blood flow is so helpful, and the gain is when paying attention to the hand's coldness beside the CTS, whether as a cause or as a result, simply advises to avoid it in favor of further relief with warmth,

The NCS is lasting the only dependable test for CTS diagnosis but still there is percentage of false negative test which push us to looking for new trusty investigations.

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