CUTANEOUS SENSIBILITY ASSESSMENT IN HEMODIALYSIS-RELATED CARPAL TUNNEL SYNDROME

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ABSTRACT

Objective: The aim of this study is to describe the use of the PSSD (Pressure specified sensory Device) for the diagnosis of carpal tunnel syndrome. Methods: The PSSD is a tool that incorporates a pressure transducer with two prongs, linked to a computer capable of measuring the cutaneous pressure thresholds. The patients were divided in two groups: Group 1- patients neither with superior limb neuropathy nor renal insufficiency. Group 2- patients with carpal tunnel syndrome related to hemodialysis. Group 2 - patients with carpal tunnel syndrome but no renal insufficiency. Results: The results showed, for two of the four parameters measured, that the group 2 had more benefits for the diagnosis of carpal tunnel syndrome than group 3. Conclusion: The PSSD is useful as a diagnostic tool in hemodialysis-related carpal tunnel syndrome Level of Evidence: Level II, development of diagnostic.

Keywords*:* Carpal tunnel syndrome/diagnosis. Renal dialysis. Nerve compression syndromes

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INTRODUCTION

Carpal tunnel syndrome is the most common compressive neuropathy of the upper limb. It is usually related to compression of the median nerve in the carpal tunnel due to a variety of factors,[1] including amyloidosis related to hemodialysis.[2,3] About 5% of patients with chronic renal failure submitted to hemodialysis present carpal tunnel syndrome.[3]

There is controversy regarding the most reliable test for the diagnosis of this condition, whereas most specialists agree that there is no gold standard. In this scenario, clinical history and physical examination continue to be the most suitable tools.[1,4-6] Electrodiagnostic tests remain the most common way to objectively find evidence of disease. However, about 10 to 15% of patients with normal electrodiagnostic studies present clinical evidence of the syndrome as well as relief of symptoms with surgical release of the carpal tunnel.[1,4]

Quantitative cutaneous sensibility tests can assist in the diagnosis of carpal tunnel syndrome in situations where physical examination leaves room for doubt, but especially when there are contradictory results between physical examination and electroneuromyography. However, there are problems such as non-universalization of the tests used, lack of precision and standardization of some types of test and absence of consensus regarding relevant information within the forms of sensibility to be assessed (temperature, pressure, movement, two-point discrimination).[7]

In an attempt to bypass these problems, Dellon et al described the PPSD (Pressure Specified Sensory Device®) in 1992.[8] The PSSD consists of an apparatus that incorporates a pressure transducer with two prongs, linked to a computer capable of measuring the cutaneous pressure thresholds. (Figure 1)

This allows the continuous measurement of pressure between 0.1 and 100 g/mm^2 and at the same time two-point discrimination capacity, with greater sensibility and precision than other tests developed previously.[9]

The use of PSSDs for diagnosing Carpal Tunnel Syndrome was described in 1997, in a study of 72 patients with suggestive clinical history, physical examination (provocative tests and Tinel's sign positive) and abnormal perception of diapason of 256 Hz.[10]

OBJECTIVE

To describe PSSD use for cutaneous sensibility assessment in chronic patients with Carpal Tunnel Syndrome submitted to hemodialysis, when compared to patients with carpal tunnel syndrome without renal failure.

All the authors declare that there is no potential conflict of interest referring to this article.

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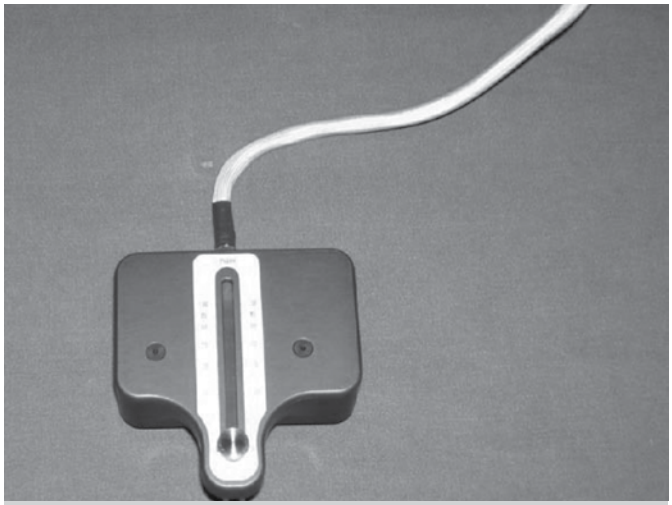

Figure 1. *Pressure transducer of the PSSD (Pressure specified-sensory Device®) – Presents two rhomboid metal prongs with distance adjustment between them, allowing variations between 2.5 and 20 mm. The transducer in turn is linked to a computer, which records the data*

PATIENTS AND METHODS

Cutaneous sensibility assessments were carried out on patients monitored in the Hand Surgery Group of the Plastic Surgery Discipline of Hospital das Clínicas of the Faculty of Medicine of Universidade de São Paulo. This project was approved by the Commission of Ethics for Analysis of Research Projects of the Hospital das Clínicas of the Faculty of Medicine of Universidade de São Paulo, under number 1247, project CAPPesq 1088/07.

The patients with a suspect diagnosis were asked to complete a standard questionnaire, containing data on history and physical examination, and always applied by the same professional. Clinical history data (nocturnal paresthesia) and compatible findings in the physical examination (Tinel's sign, Phalen's sign) were gathered for inclusion in the protocol. Patients with inconsistent clinical history and doubtful questionable physical examination were referred for electrodiagnostic testing. The diagnosis was considered positive when the patient presented improvement of symptoms in the postoperative period.

The patients were divided into three groups:

Group 1 - Patients without proven pathology, both renal and in peripheral nerves of the upper limbs, as a control group.

Group 2 – patients with carpal tunnel syndrome and with chronic renal failure in hemodialysis program.

Group 3 – patients with carpal tunnel syndrome without renal failure.

Patients with carpal tunnel syndrome already operated previously, patients with a prior history of upper motor neuron lesion, patients unable to perform the necessary motor functions for performance of the test and patients unable to understand instructions were excluded from the protocol.

Fifty-three patients were included in the study. Of these, 29 had carpal tunnel syndrome. In group 1 there were 24 patients included in the study, with 45 hands evaluated. In group 2 there were 14 patients studied, with 22 hands evaluated. In group 3, 15 patients were included with 21 hands examined.

The mean age of the patients in the groups with carpal tunnel syndrome was 51.1 years, ranging from 28 to 77 years (51.7 years for group 2 and 50.5 years for group 3). In the control group, the mean age was 41.4 years, ranging from 19 to 72 years.

The patients from group 2 presented mean hemodialysis time of 16.2 years, ranging from 8 to 28 years. All the patients presented the condition on the side with the fistula, whereas 57% of these presented it bilaterally. In the patients from group 3, 46% presented bilateral condition.

A positive Tinel's sign, defined as appearance of paresthesiae in the median nerve distribution produced by the percussion of this nerve in the wrist region; was present in 83% of the patients (90.9% of the patients from group 2 and in 75% of the patients from group 3).

A positive Phalen's sign, defined as appearance or increase of paresthesiae in the territory of the median nerve in 60 seconds after flexion of the wrists, was present in 80.9% of the patients. In the patients that underwent hemodialysis, it was present in 95.4%, while in the individuals without kidney disease, it was present only 65% of the time.

Nocturnal paresthesia was present on 74% of the occasions; and was referred to by 78% of the patients from group 2 and by 69.2% of the patients from group 3.

Thenar atrophy was verified in just 11.1% of the patients.

The sensibility tests were executed using the PSSD (Pressure-Specified Sensory Device® - NK Biotechnical Engineering Co.). The PSSD is an instrument equipped with two parallel rhomboid metal prongs (Figure 1), where the distance between these extremities can be adjusted by the examiner (from 2.5 to 20 mm). These extremities in turn are linked to pressure transducers, which allow examiners to verify the application force on the skin of each one of them (for one-point measurements of pressure), or of both (for two-point measurement). The PSSD is linked to a computer, allowing the viewing of data on the screen and also their analysis and storage. (Figure 2)

The order for performance of the examination was established as follows: determination of two-point discrimination, using the Diskriminator® and considering the distance correct when the patient got seven out of every ten answers right (for example, two-point discrimination will be considered 3mm if the patient is able to recognize that there are two prongs touching their fingertips in seven out of ten attempts), following guidelines from the protocols of the American Society for Surgery of the Hand.

The cutaneous pressure threshold examination is started next. Measurements are recorded for the single-point static test (1 LP) and single-point dynamic test (1 RP), measuring the function of the fibers for light touch sensation (Aß) of slow adaptation and fast adaptation, respectively.

This is followed by the two-point cutaneous pressure threshold tests, namely: two-point static test (2 LP) and the two-point dynamic test (2 RP). For these exams, the examiner will adjust the distance between the two extremities of the device for the result obtained in the two-point discrimination test described previously. The complete exam takes about 40 minutes.

Figure 2. *Overview of the PSSD: From left to right we see the pressure transducer, the acoustic warning device and the computer in which the data are analyzed and stored.*

The results of the control group were computed and evaluated. The group was divided into patients under 45 years of age and patients over 45 years of age, according to the study conducted by Dellon with US population normative data.[8,9] The examiners calculated the mean, standard deviation and confidence interval of 99%.

The results obtained in the four parameters (1 LP, 1 RP, 2 LP, 2 RP) were classified as normal or altered, according to values determined by the control group; and compared with one another using Fisher's exact test. Values above those encountered in the confidence interval of 99% of the control group were considered abnormal. The sensibility of the static and dynamic tests was also calculated.

RESULTS

The results of the sensibility tests with the patients from groups 1, 2 and 3 are summarized in Tables 1, 2 and 3.

In the tests from a static point and a dynamic point the patients from group 2 exhibited greater sensibility for the detection of carpal tunnel syndrome than the patients from group 3; with statistically significant difference. (Table 4)

DISCUSSION

Hemodialysis-dependent patients with chronic renal failure may develop carpal tunnel syndrome, due to mechanisms that are still controversial. The true pathogenesis is not fully understood, and may possibly be multifactorial. One of the hypotheses is that the arteriovenous fistula would lead to segmental ischemia of the median nerve due to hemodynamic disorders, neuritis caused by external compression of the median nerve or edema induced by actual anastomosis. Several studies have demonstrated the association between b_2-microglobulin deposits in the carpal tunnel and the appearance of the condition. The syndrome incidence increases with the number of years the patient is submitted to hemodialysis.[11,12] The diagnosis of carpal tunnel syndrome is still considered by most specialists to be clinical.[1,4-6] However, the signs and

Table 1. *Values of the cutaneous pressure thresholds (g/mm²) in patients from Group 1.*

		1 LP	1 RP	2 LP	2 RP
< 45 years	Mean	0.364	0.404	0.536	0.5052
	Standard deviation	0.118	0.16	0.246	0.173
	Confidence interval 99%	0.442	0.509	0.698	0.619
> 45 years	Mean	0.508	0.489	0.564	0.588
	Standard deviation	0.257	0.241	0.236	0.254
	Confidence interval 99%	0.688	0.658	0.73	0.767

NOTE: 1LP- single-point static test, 1RP- single-point dynamic test, 2LP- two-point static test. 2RP- two-point dynamic test.

Table 2. *Values of the cutaneous pressure thresholds (g/mm²) in groups 2 and 3.*

	Static tests		Dynamic tests		Two-point discrimination
	1LP	2 LP	1 RP	2RP	
Total mean (g/mm2)	2.255	3.532	1.59	3.079	6.14 mm
Mean group 2 (g/mm2)	3.36	3.455	2.11	3.453	6.61 mm
Mean group 3 (g/mm2)	1.875	3.605	1.04	2.705	5.6 mm

Table 3. *Sensibility for carpal tunnel syndrome diagnosis using the PSSD for groups 2 and 3.*

	Static tests		Dynamic tests	
	1LP	2 LP	1 RP	2RP
Total sensibility	76.7%	97.6%	74.4%	95.2%
Sensibility group 2	95.4%	100%	100%	100%
Sensibility group 3	54.5%	95.2%	47.6%	90.4%

Table 4. *p-values for Fisher's exact test, used for comparison between groups 2 and 3. There was a statistically significant difference for tests 1 LP and 1RP.*

Test	Group 2 x Group 3
1 LP	p = 0.0036
1 RP	p= 0.0001
2 LP	p= 0.4884
2 RP	p= 0.2326

symptoms are not always clearly indicative of the condition; and in these situations one should turn to integrated propedeutics. Electrodiagnostic tests are used the most often, and considered gold standard. However, they present an incidence of up to 15% of false negative results in clinical studies.[1,4]

Gousheh *et al.,* in a study with 279 patients, demonstrated even greater incidence of false negative results in electrodiagnostic studies on patients undergoing hemodialysis with carpal tunnel syndrome, challenging the validity of their results in this kind of patient.[3]

Quantitative cutaneous sensibility exams were introduced into clinical practice by Weber in 1835 (two-point discrimination) and by von Frey in 1905. There are two types of quantitative cutaneous sensibility exam: the cutaneous pressure threshold tests and the two-point discrimination tests. The cutaneous pressure threshold takes into account the relationship of the nerve fiber with its receptor. The threshold is a physical property that is measured in response to a defined stimulus, representing a point along a physical spectrum below which there is no detection of the existence of an event and above which there is awareness of its existence. Two-point discrimination, in turn, is related to the density of fibers. Both aspects are obviously important and cannot be dissociated.[9]

The cutaneous pressure threshold test used most often is that of Semmes- Weinstein. This exam allows an estimate of intervals of perception of the threshold of patients. This limitation of the test (inability to obtain continuous results) is a problem inherent to the exam, which may, for instance, fail to detect an alteration of cutaneous sensibility if this remains within the same interval measured previously.[9]

In the mid-sixties of the last century, Moberg announced the importance of two-point discrimination as a measurement related to hand function. However, the impossibility of gauging the application pressure of the measuring devices on the skin has remained as a problem to be resolved. At the same time it cannot be the only exam to be performed, since the loss of nerve fibers is usually a late event in diseases such as the compressive neuropathies.[9]

In 1992, Dellon *et al.* introduced the use of a computerized cutaneous sensibility assessment test, the PSSD (Pressure Specified Sensory Device), which measures the cutaneous pressure thresholds for the distinction of one or two points, enabling the use of a pressure perception parameter not formerly available. This exam proved more sensitive than the traditional electrodiagnostic studies in the detection of chronic compression of the peripheral nerves.[8,10]

The sensibility assessment performed through the PSSD embodies the two main aspects of cutaneous sensibility: measurement of the cutaneous pressure threshold and two-point discrimination. Each one of these parameters will evaluate different aspects of peripheral nerve function, with unique advantages such as the continuous measurement of the cutaneous pressure threshold (unlike the Semmes-Weinstein test, which as mentioned previously measures value intervals) and the possibility of controlling pressure exerted on the skin by the device in the two-point discrimination measurement; thus adding acuity in the exam (we no longer measure just the distance between two points, but also the lowest pressure at which the individual perceives that there are two points and not just one).

At the same time, measuring the cutaneous thresholds in the static and dynamic categories, we are evaluating different types of nerve fiber (of slow or fast adaptation, respectively) and different receptors.[8-10]

The results of this study showed resemblance to the study by Dellon *et al.*[10] with patients exhibiting upper arm compression syndromes. The most effective parameters for the diagnosis of carpal tunnel syndrome, in other words, those with greater sensibility, were the two-point tests, both static and dynamic (2 LP and 2 RP). Thus two-point tests appear to be ideal for use as screening, since they suffer alteration at an earlier stage both for patients from group 2 and for patients from group 3.

Now the single-point tests (1 LP and 1 RP) were more sensitive for the diagnosis of carpal tunnel syndrome in the chronic kidney patients from group 2 than with patients from group 3. These data can reflect differences in the severity of the pathology in patients from group 2, since the physiopathology of the syndrome in these patients is different, and related to the accumulation of b2-microglobulin in the transverse carpal ligament.[3]

In this manner, the PSSD can serve as an alternative to electrodiagnostic tests, particularly for patients with chronic renal failure, where literature demonstrates the presence of a high rate of false negative results. Moreover, the fact that the cutaneous sensibility test is less uncomfortable for the patient could facilitate treatment control with better adhesion, in view of the decreased need for repetition of electrodiagnostic tests.

One disadvantage of the PSSD is the time required for execution of the exam. The results of the kappa equivalence tests demonstrated that, to diagnose carpal tunnel syndrome, it would not be necessary to perform the two single-point tests, since there is a high equivalence between both. In this manner we could measure one parameter less, thus abbreviating the test.

The possibility of independently measuring different subtypes of fibers associated with light touch sensation, may allow a more trustworthy follow-up of the control over treatment of peripheral nerve pathologies, including more specific directions for sensory rehabilitation if necessary, yet requiring further studies to evaluate this kind of benefit.

Furthermore, the existence of a sensibility exam with objective and continuous values opens up perspectives for the creation of a peripheral nerve compression severity scale, besides the possibility of performing new assessments with objective data on the patient's clinical improvement. This has already been established by Dellon *et al.*[8] and Dellon and Keller[10] in their studies on lower limb compression neuropathy in diabetic patients and applied successfully.[15]

Other situations could potentially benefit from this type of exam, including, for example, ulnar nerve entrapment syndromes in

the cubital tunnel, which is known to present a high rate of false negative results in electrodiagnostic studies.[16]

The precise indications for the cutaneous sensibility tests are not yet established, but the universalization and standardization of the type of data gathered and their study for peripheral nerve pathologies, whether compressive or traumatic, are certainly urgent matters. Nowadays the quest for treatment optimization involves not only effective motor recovery, but also satisfactory re-establishment of cutaneous sensibility. To enable efficient treatment protocols to be established, it is necessary to have more adequate monitoring of sensory recovery in all its aspects. Electrodiagnostic tests will continue to have their importance, yet nerve conduction does not necessarily signify function. Within this context, cutaneous sensibility tests should be conducted in pursuit of a clearer path in sensory reeducation and therefore in the recovery of the hand's overall function.

CONCLUSIONS

For the static single-point exam (1 LP), the patients with carpal tunnel syndrome related to hemodialysis presented greater sensibility in the syndrome diagnosis, when compared with patients without kidney disease.

For the dynamic single-point exam (1 RP), the patients with carpal tunnel syndrome related to hemodialysis presented greater sensibility in the syndrome diagnosis; when compared with patients without kidney disease.

For the two-point tests, both static and dynamic (2 LP and 2 RP), there was no statistically significant difference for the diagnosis of carpal tunnel syndrome between groups 2 and 3.

REFERENCES

1. Akelman E. Carpal tunnel syndrome. In: Berger R, Weiss AP, editors. Hand surgery. Philadelphia: Lippincot Williams & Wilkins; 2004. p. 867-85.
2. Buchs JB, Zbrodowski A. [Circulatory repercussions of arteriovenous fistulae at the carpal tunnel level]. J Urol (Paris). 1983;89:183-6.
3. Gousheh J, Iranpour A. Association between carpel tunnel syndrome and arteriovenous fistula in hemodialysis patients. Plast Reconstr Surg. 2005;116:508-13.
4. Hentz VR, Lalonde DH. MOC-PS(SM) CME article: self-assessment and performance in practice: the carpal tunnel. Plast Reconstr Surg. 2008;121(4 Suppl):1-10.
5. LaJoie AS, McCabe SJ, Thomas B, Edgell SE. Determining the sensitivity and specificity of common diagnostic tests for carpal tunnel syndrome using latent class analysis. Plast Reconstr Surg. 2005;116:502-7.
6. Szabo RM, Slater RR Jr, Farver TB, Stanton DB, Sharman WK. The value of diagnostic testing in carpal tunnel syndrome. J Hand Surg Am. 1999;24:704-14.
7. Novak CB, Mackinnon SE, Williams JI, Kelly L. Establishment of reliability in the evaluation of hand sensibility. Plast Reconstr Surg. 1993;92:311-22.
8. Dellon ES, Mourey R, Dellon AL. Human pressure perception values for constant and moving one- and two-point discrimination. Plast Reconstr Surg. 1992;90:112-7.
9. Dellon AL. Somatosensory testing and rehabilitation. Bethesda Maryland: American Occupational Therapy Association; 1997. p.299-343.
10. Dellon AL, Keller KM. Computer-assisted quantitative sensorimotor testing in patients with carpal and cubital tunnel syndromes. Ann Plast Surg. 1997;38:493-502.
11. Warren DJ, Otieno LS. Carpal tunnel syndrome in patients on intermittent haemodialysis. Postgrad Med J. 1975;51(597):450-2.
12. Naito M, Ogata K, Goya T. Carpal tunnel syndrome in chronic renal dialysis patients: clinical evaluation of 62 hands and results of operative treatment. J Hand Surg Br. 1987;12:366-74.
13. Dellon ES, Keller KM, Moratz V, Dellon AL. Validation of cutaneous pressure threshold measurements for the evaluation of hand function. Ann Plast Surg. 1997;38:485-92.
14. Mountcastle VB, Talbot WH, Darian-Smith I, Kornhuber HH. Neural basis of the sense of flutter-vibration. Science. 1967;155(762):597-600.
15. Dellon AL. Treatment of symptomatic diabetic neuropathy by surgical decompression of multiple peripheral nerves. Plast Reconstr Surg. 1992;89:689-97.
16. Husain SN, Kaufmann RA. The diagnosis and treatment of cubital tunnel syndrome. Curr Orthop Pract 2008;19:470-3.