ประโยชน์ของวิธีการตรวจไฟฟ้าวินิจฉัยเพิ่มเติมในการวินิจฉัยภาวะเส้นประสาทมีเดียนถูกกดทับบริเวณข้อมือในผู้ป่วยที่มีภาวะเส้นประสาทส่วนปลายผิดปกติจากเบาหวาน

ชินภัทร์ จิระวรพงศ์
ภาควิชาเวชศาสตร์ฟื้นฟู คณะแพทยศาสตร์ มหาวิทยาลัยนเรศวร อ.เมือง จ.พิษณุโลก 65000

Usefulness of Additional Electrodiagnostic Techniques for Median Neuropathy at the Wrist (Carpal Tunnel Syndrome) in Patients with Diabetic Polyneuropathy

Chinapat Gerawarapong
Department of Rehabilitation Medicine, Faculty of Medicine, Naresuan University, 65000 Thailand
Email: chinapatjqka@gmail.com, chinapatg@nu.ac.th

ภาวะเส้นประสาทส่วนปลายผิดปกติในผู้ป่วยเบาหวาน (diabetic polyneuropathy; DPN) เป็นภาวะแทรกซ้อนที่พบได้บ่อยในผู้ป่วยเบาหวานชนิดที่ 1 และ 2 ซึ่งเกิดขึ้นได้ถึงร้อยละ 50 ของผู้ป่วยเบาหวานทั้งหมด พยาธิสภาพของภาวะ DPN สามารถพบเป็น segmental demyelination หรือ axonal degeneration ทั้ง large และ small neural fibers ได้โดยเฉพาะในผู้ป่วยเบาหวานที่ควบคุมระดับน้ำตาลในเลือดได้ไม่ดี ภาวะเส้นประสาทมีเดียนถูกกดทับบริเวณข้อมือหรือกลุ่มอาการ carpal tunnel syndrome (CTS) ซึ่งพบได้บ่อยในผู้ป่วยเบาหวานที่มีภาวะ DPN กลุ่มอาการ CTS และภาวะ DPN สามารถพบร่วมกันและยากแก่การวินิจฉัยแยกโรคด้วยการตรวจไฟฟ้าวินิจฉัย (electrodiagnostic; EDX study) ในปัจจุบันยังไม่มีการตั้งเกณฑ์ EDX ในการวินิจฉัยกลุ่มอาการ CTS ในผู้ป่วยเบาหวานที่มีภาวะ DPN บทความฉบับนี้มีวัตถุประสงค์เพื่อสืบค้นและทบทวนวิธีการตรวจไฟฟ้าวินิจฉัยเพิ่มเติมในการวินิจฉัยกลุ่มอาการ CTS ในผู้ป่วยกลุ่มนี้ เช่น distoproximal latency ratio (DPLR), wrist-palm median sensory conduction velocity (W-P SCV), 2nd lumbrical-interosseous median-ulnar distal latency difference (2nd LIMULD) และ median-radial distal sensory latency difference (M-RSLD) โดยสรุปแล้ว

Diabetic polyneuropathy (DPN) is a most common complication of both type 1 and type 2 diabetes mellitus (DM) which affects up to 50% of the patients. Pathological features in DPN have shown segmental demyelination or axonal degeneration which involving in both large and small neural fibers in poorly controlled diabetic patients. The carpal tunnel syndrome (CTS) has been reported to be more frequent in diabetic patients with DPN. The CTS and DPN often coexist and can be difficult to distinguish by electrodiagnostic (EDX) study. EDX criteria of CTS in diabetic patients with DPN have not been established. The objective of this article are finding out and review the literatures, which studied the additional EDX studies such as distoproximal latency ratio (DPLR), wrist-palm median sensory conduction velocity (W-P SCV), 2nd lumbrical-interosseous median-ulnar distal latency difference (2nd LIMULD), and median-radial distal sensory latency difference (M-RSLD). Conclusion, the additional EDX techniques are recommended: 1) 2nd LIMULD for motor nerve conduction study (NCS). And 2) DPLR or 3) W–P SCV with comparative tests (such as M-RSLD and M-USLD) for sensory NCS in combination with standard

การตรวจไฟฟ้าวินิจฉัยเพิ่มเติมสำหรับ motor nerve conduction study (NCS) ควรใช้เทคนิค 1) 2nd LIMULD ส่วน sensory NCS ควรใช้เทคนิค 2) DPLR หรือ 3) W–P SCV ร่วมกับการตรวจ sensory NCS อื่นๆ เช่น median-radial distal sensory latency difference (M-RSLD) และ median-ulnar distal sensory latency difference (M-USLD) ประกอบในการตรวจไฟฟ้าวินิจฉัยด้วยวิธีมาตรฐานจะทำให้การวินิจฉัยกลุ่มอาการ CTS ในผู้ป่วยเบาหวานที่มีภาวะ DPN มีความแม่นยำมากยิ่งขึ้น

คำสำคัญ: เบาหวาน, ภาวะเส้นประสาทส่วนปลายผิดปกติ, ภาวะเส้นประสาทมีเดียนถูกกดทับบริเวณข้อมือ, การตรวจไฟฟ้าวินิจฉัย, distoproximal latency ratio, wrist-palm median sensory conduction velocity, 2nd lumbrical-interosseous median-ulnar distal latency difference, median-radial distal sensory latency difference

NCS techniques should result in more accurate diagnosis of CTS in DPN patients.

Keywords: diabetic polyneuropathy, carpal tunnel syndrome, electrodiagnostic study, distoproximal latency ratio, wrist-palm median sensory conduction velocity, 2nd lumbrical-interosseous median-ulnar distal latency difference, median-radial distal sensory latency difference

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Introduction

Diabetic polyneuropathy (DPN) is a most common complication of both type 1 and type 2 diabetes mellitus (DM) which affects up to 50% of the patients[1]. Pathological features in DPN have shown segmental demyelination or axonal degeneration which involving in both large and small neural fibers[2,3]. The DPN often caused by metabolic microangiopathy in poorly controlled diabetic patients[4]. Length dependent, symmetrical sensori-motor polyneuropathy represents its most frequent form, primarily affecting in feet and lower limbs[5]. Early detection of the DPN enables interventions to prevent long-term complications, such as diabetic foot ulcers and limb amputations[6]. Its symptoms are ranging from unpleasant feeling, dysesthesia or numbness to severe pain[7,8]. Gold standard for diagnosis DPN is conventional electrodiagnostic (EDX) study especially included with nerve conduction study (NCS) and needle electromyography (EMG)[3,9].

Carpal tunnel syndrome (CTS) is the most common entrapment neuropathy caused by compression of median nerve (median neuropathy) as it passes through the carpal tunnel at the wrist[3,10]. Diagnosis of CTS is usually based on a combination of clinical symptoms and EDX findings which important for appropriate treatment planning[11]. Clinical diagnosis of CTS was based on the presence of the followings[12,13]:

At least one of the sensory symptoms (numbness, tingling, burning or pain) in median nerve distribution.

At least one of the provocative or mitigating factors: sleep, sustained position, repetitive actions, hand shaking or hand position change.

At least one of the following signs: positive test of Tinel's sign or Phalen's test, sensory loss or weakness in median nerve distribution.

Recommendations regarding EDX studies to confirm a clinical diagnosis of CTS

The recommendations below are developed in 1993 by the American Academy of Neurology, the American Academy of Physical Medicine and Rehabilitation and the American Association of Electrodiagnostic Medicine (AAEM) with the clarification of recommendation 1 and 2a and the addition of 2c based on new evidence reviewed in the CTS literature review [14,15].

EDX techniques designed to assist in the diagnostic of CTS can be helpful to evaluate the electrophysiological status of both motor and sensory neural fibers through the carpal tunnel with appropriated sensitivities and specificities (Table 1)[3,14].

Table 1 Comparison of pooled sensitivities and specificities of EDX techniques to diagnose CTS[14].

	Technique	Pooled sensitivity	Pooled specificity
A*	Median sensory and mixed nerve conduction: wrist and palm segment compared to forearm or digit segment	0.85 (0.83, 0.88)	0.98 (0.94, 1.00)
B*	Comparison of median and ulnar sensory conduction between wrist and ring finger	0.85 (0.80, 0.90)	0.97 (0.91, 0.99)
C*	Median sensory and mixed nerve conduction between wrist and palm	0.74 (0.71, 0.76)	0.97 (0.95, 0.99)
D*	Comparison of median and ulnar mixed nerve conduction between wrist and palm	0.71 (0.65, 0.77)	0.97 (0.91, 0.99)
E	Median motor nerve conduction between wrist and palm	0.69 (0.64, 0.74)	0.98 (0.93, 0.99)
F*	Comparison of median and radial sensory conduction between wrist and thumb	0.65 (0.60, 0.71)	0.99 (0.96, 1.00)
G*	Median sensory nerve conduction between wrist and digit	0.65 (0.63, 0.67)	0.98 (0.97, 0.99)
I	Median motor nerve terminal latency index	0.62 (0.54, 0.70)	0.94 (0.87, 0.97)
J	Comparison of median motor nerve distal latency (second lumbrical) to the ulnar motor nerve distal latency (second interosseous)	0.56 (0.46, 0.66)	0.98 (0.90, 1.00)
K	Sympathetic skin response	0.04 (0.00, 0.08)	0.52 (0.44, 0.61)

* AAEM recommendation based on new evidence reviewed in the CTS literature review[14, 15]

In patients who suspected of CTS, the following EDX studies are recommended (Table 1)[14, 15]:

(1) Perform a median sensory NCS across the wrist with a conduction distance of 13 to 14 cm (Technique G). If the result is abnormal, comparison of the result of the median sensory NCS to the result of a sensory NCS of one other adjacent sensory nerve in the symptomatic limb (Standard).

(2) If the initial median sensory NCS across the wrist has a conduction distance greater than 8 cm and the result is normal, one of the following additional studies is recommended:

a) Comparison of median sensory or mixed nerve conduction across the wrist over a short (7 to 8 cm) conduction distance (Technique C) with ulnar sensory nerve conduction across the wrist over the same short (7 to 8 cm) conduction distance (Technique D) (Standard), or

b) Comparison of median sensory conduction across the wrist with radial or ulnar sensory conduction across the wrist in the same limb (Techniques B and F) (Standard), or

c) Comparison of median sensory or mixed nerve conduction through the carpal tunnel to sensory or mixed NCSs of proximal (forearm) or distal (digit) segments of the median nerve in the same limb (Technique A) (Standard).

(3) Motor NCS of the median nerve recording from the thenar muscle (Technique H) and of one other nerve in the symptomatic limb to include measurement of distal latency (Guideline).

(4) Supplementary NCS: comparison of the median motor nerve distal latency (second lumbrical) to the ulnar motor nerve distal latency (second interosseous) (Technique J); median motor terminal latency index (Technique I); median motor nerve conduction between wrist and palm (Technique E); median motor nerve compound muscle action potential (CMAP) wrist-to-palm amplitude ratio to detect conduction block; median sensory nerve action potential (SNAP) wrist-to-palm

amplitude ratio to detect conduction block; short segment (1 cm) incremental median sensory nerve conduction across the carpal tunnel (Option).

(5) Needle electromyography (EMG) of a sample of muscles innervated by the C_5 to T_1 spinal roots, including a thenar muscle innervated by the median nerve of the symptomatic limb (Option).

EDX criteria of CTS should include at least two of the following (Table 2):

The CTS has been reported to be more frequent in diabetic patients with DPN than in general population[17, 18]. The CTS and DPN often coexist and can be difficult to distinguish by EDX findings in clinical practice[18-20], because CTS and DPN may produce similar abnormalities in median NCS. The use of EDX criteria in these patients results in a high rate of false-positive diagnosis. On the other hand, uncertainty of the EDX criteria of CTS in diabetic patients with DPN, have not been established[14-20].

Usefulness of Additional Electrodiagnostic Techniques for Median neuropathy at the wrist (Carpal Tunnel Syndrome) in Patients with Diabetic Polyneuropathy

AAEM recommended guidelines for the study of CTS, which include looking at the median nerve sensory conduction across short segments. By comparing a proximal sensory segment across the carpal ligament with a more distal segment, it is possible to differentiate between CTS and DPN[16-21]. The CTS patients will have more slowing nerve conduction velocity (NCV) across the carpal ligament, while the DPN involves more distal nerves commonly in the upper extremity, especially the ulnar and median nerves will be involved. While in the CTS, the median nerve will be significantly slowed.

The objectives of this article are finding out and review the literatures, in the year 2005-2011[16-27], which studied the additional EDX studies distoproximal latency ratio (DPLR)[16, 20, 22-26], wrist-palm median sensory conduction velocity (W-P SCV)[18, 23-25], 2nd lumbrical-interosseous median-ulnar distal latency difference (2nd LIMULD)[17, 20, 26], median-radial distal sensory latency difference (M-RSLD)[25, 27], have been proposed to determine CTS with DPN, but there is no consensus of these tests is most reliable[16, 17, 21].

The Distoproximal latency ratio (DPLR) and Wrist-palm median sensory conduction velocity (W-P SCV)

The median nerve was obtained antidromically, it was stimulated 3 cm proximal to the distal wrist crease, and 3 cm distal to the distal wrist crease (mid-palm), recording by ring electrodes from the index finger[22-25]. Median palm digit and wrist palm latencies compared by using the distoproximal latency ratio (DPLR) (Fig 1). It is calculated as follows: DPLR = palm digit latency/[wrist digit latency - palm digit latency][16, 20, 22-26]. Wrist-palm median sensory conduction velocity (W-P SCV) [17, 23-25] was calculated using distal latency difference of the median nerve at the time of wrist and palm stimulation (Fig 2).

Table 2 The EDX techniques & criteria of CTS[3, 15, 16].

EDX technique	DSL (msec)	DML (msec)	Amplitude (μV)	NCV (m/s)
Distal motor latency (DML) of the median nerve†	-	2.2-4.2	5000-25000	50-60
Median DML of APB muscle compared to ulnar DML of ADM muscle†	-	1.0		
Distal sensory latency (DSL) of median nerve, digit 2 ††	2.9-3.6	-	10-100	48-65
Median DSL of digit 2 compared to ulnar DSL of digit 5 ††	≤ 0.5	-	-	-
Median DSL of digit 4 compared to ulnar DSL of digit 4††	≤ 0.6	-	-	-

†(8 cm distance); ††(14 cm distance); APB: Abductor pollicis bravis; ADM: Abductor digiti minimi

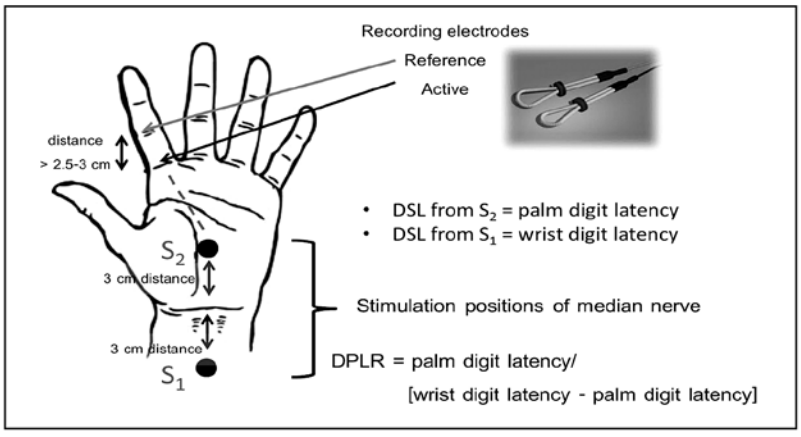

Figure 1 The positions of stimulating and recording electrodes for measurement of Distoproximal latency ratio (DPLR)[22-25].

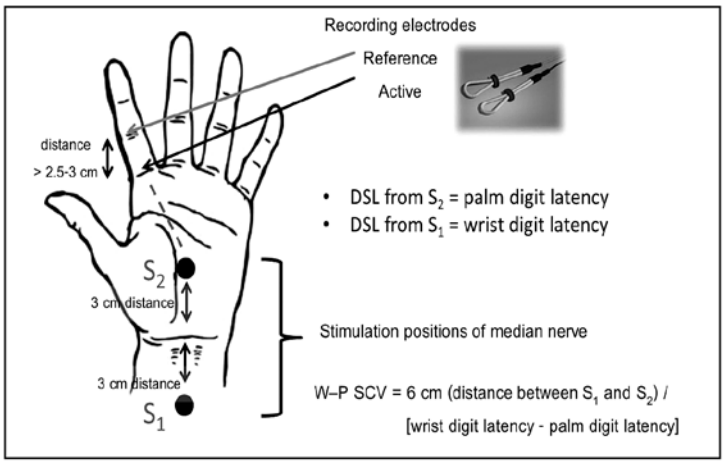

Figure 2 The positions of stimulating and recording electrodes for measurement of Wrist-palm median sensory conduction velocity (W-P SCV)[23, 25].

The DPLR for the cut-off value of 1.0, and median-ulnar distal sensory latency difference (M-USLD) to digit 4 for the cut-off value of 0.35, showed the highest sensitivity (90% for both DPLR and M-USLD) and specificity (81% for DPLR, 85% for M-USLD) in the diagnosis of CTS in DPN patients ($n_{CTS+DPN\ group}$ = 62, $n_{CTS\ group}$ = 140, n_{total} = 349 hands)[25].

Wrist-palm median sensory conduction velocity (W-P SCV)[23, 25], with the cut-off value of 41.4 m/sec, showed high sensitivity (85%) and specificity (77%). It could be a useful technique for EDX of CTS in DPN patients ($n_{CTS+DPN\ group}$ = 62, $n_{CTS\ group}$ = 140, n_{total} = 349 hands)[25].

The 2nd lumbrical-interosseous median-ulnar distal latency difference (2nd LIMULD)

The 2nd lumbrical-interosseous median-ulnar distal latency difference (2nd LIMULD) is comparison study of median distal motor latency (2nd lumbrical) to the ulnar distal motor latency (2nd interosseous). The 2nd LIMULD with a distance of 3 cm proximal to distal wrist crease and 8 cm from cup-shaped active electrode at 2nd lumbrical and interosseous muscles (Fig 3). The 2nd LIMULD can identify the CTS in diabetic DPN patients (sensitivity of 88.4%) better than median-radial distal sensory latency difference (M-RSLD) with a distance of 9 cm (sensitivity of 73%), and M-USLD with a distance

of 12-13 cm (sensitivity of 54%). The difference values are more than 0.4 msec for 2nd LIMULD, 0.5 msec for both M-RSLD and M-USLD ($n_{CTS+DPN\ group} = 43$, $n_{CTS\ group} = 45$, $n_{total} = 180$ hands)[26].

The median-radial distal sensory latency difference (M-RSLD)

The M-RSLD to digit 1 (distance of 9 cm, cut-off value of 0.55 msec) showed high sensitivity (82%) and specificity (80%) for CTS patients with DPN ($n_{CTS+DPN\ group} = 62$, $n_{CTS\ group} = 140$, $n_{total} = 349$ hands)[25].

And the other study, combined sensory index (CSI) showed the M-RSLD (distance of 10 cm, cut-off value of 0.5 msec; or thumb-diff) (Fig 4) had high sensitivity (100%) but low specificity (52.2%). The M-USLD (distance of 14 cm, cut-off value of 0.4 msec; or ring-diff) and orthodromic median-ulnar distal sensory latency difference (distance of 8 cm, cut-off value of 0.3 msec; or palm-diff) also had high sensitivity (100%) with moderate to high specificity (82%) in the CTS patients with DPN (n = 52 hands)[27].

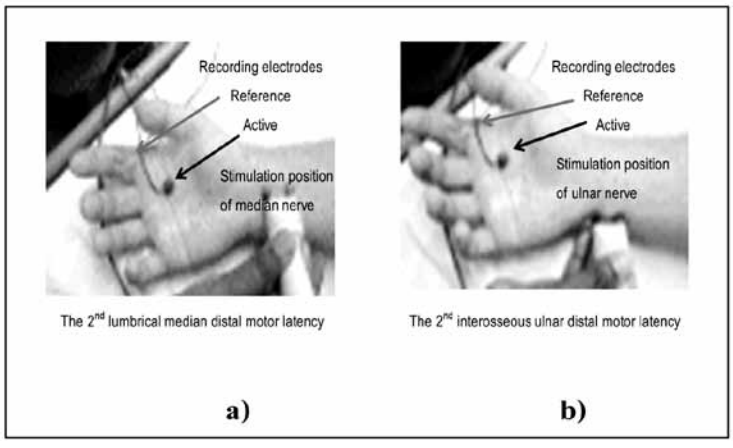

Figure 3 The positions of stimulation and recording electrodes of the comparison study of latency difference between a) median distal motor latency (2nd lumbrical muscle) to the b) ulnar distal motor latency (2nd interosseous muscle)[26]

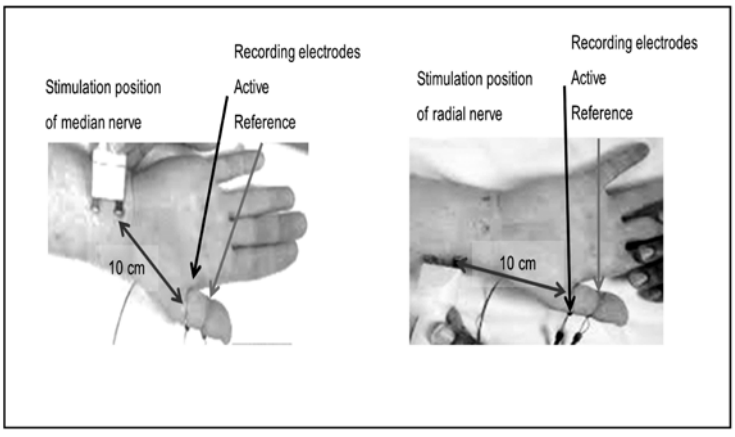

Figure 4 The positions of stimulation and recording electrodes of the median-radial distal sensory latency difference (M-RSLD) study[25, 27]

Conclusion

Segmental median NCSs like the DPLR or W-P SCV and sensory comparative tests, such as M-RSLD and M-USLD, in combination with standard NCS techniques should result in more accurate diagnosis of sensory involved CTS in DPN patients. Among the motor NCS, the 2nd LIMULD also is additional usefulness technique in motor involved CTS in DPN patients.

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