A Rapid, Low-cost, Point-of-care Test for Diabetic Peripheral Neuropathy

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Background

Annual monitoring of diabetic peripheral neuropathy (DPN) is recommended for early detection of this microvascular complication and to track its progression. The most widely utilized testing method is the 5.07/10-g monofilament. Nerve conduction studies (NCS) are the most accurate and reproducible test for DPN. However, they are not typically used for early detection, confirmation, or monitoring of DPN due to their expense, limited availability, and complexity. In response, we developed a fast, low-cost, point-of-care device called NC-stat DPNCheck which measures sural nerve conduction velocity (CV) and sensory nerve action potential (SNAP) amplitude.

As a measure of nerve conduction, we hypothesized that this test would have a strong association with HbA1c.

Device Description

NC-stat® DPNCheck™ is based on the widely used and validated NC-stat device (Perkins et al. 2006, Perkins et al. 2008, Kong et al. 2008). The device is designed to rapidly measure sural nerve conduction.

Device specifications are shown in the Table below. A labeled picture of the device in shown in the Figure below. The system consists of two main components:

- A hand-held device that includes the hardware and software necessary to stimulate the sural nerve, acquire the evoked response and determine CV and SNAP amplitude.
- A biosensor consisting of an array of bioelectrical recording electrodes.

Hardware Specifications

Channels	2
CMRR (typical)	>100 dB
Gain	x1000
Noise (typical)	<1 µV rms
Frequency Response (-3 dB)	2 Hz – 2 kHz
Sampling Frequency	10 kHz
ADC Resolution	16 bits (effective)
Stimulator Type	Constant current, monophasic
Stimulator Max Voltage	410 V
Stimulator Max Current	60 mA
Stimulator Pulse Width	100 µs
Stimulation Frequency	1 Hz
Skin Temperature Measurement	Non-contact, infrared
Battery	3.0 V Lithium Primary (CR123A)

Methods

Sural CVs were measured bilaterally. In addition to the most recent HbA1c (range 4.7-10.3), the following variables were modeled: age, height, diabetes type and duration. The relationship between HbA1c and CV was evaluated by multivariate regression with the final model retaining variables at $p<0.1$. This study was a prospective single site study. Fifteen consecutive subjects (8 female) with diabetes mellitus (DM; 3 Type I, 12 Type II) who responded to study recruitment notices were evaluated. Ages ranged from 33 to 76 yrs and disease durations from 1 to 24 yrs.

Results

Complete tests were performed in 29 sural nerves; excessive signal variability prevented evaluation of 1 nerve. The average data collection time was 10±5 (range 2-16) seconds per nerve. 25 nerves had a detectable response (>1.5 µV) from which a CV could be determined (range 23.3-48.8 meter/sec). The remaining 4 nerves were undetectable and no CV was reported. The regression analysis demonstrated a statistically significant ($p=0.001$) and clinically meaningful 2.1 meter/sec decrease in CV for every 1% increase in HbA1c. Age, height, and diabetes duration were also associated with CV.

Summary

In previous studies performed using traditional NCS techniques, sural CV decreased by about 1-3 meter/sec for every 1% increase in HbA1c. In the present study, point-of-care sural CV exhibited a similar association to HbA1c. However, unlike time consuming traditional techniques, this test required only 30-60 seconds per nerve including preparation. Rapid, low-cost, point-of-care sural nerve conduction testing has the potential to improve DPN detection and monitoring.

References

Perkins, et al. *Diabetes Care.* 2006;29.
Perkins, et al. *Diabetes Care.* 2008;31.
Kong, et al. *J Diabetes Sci Technol.* 2008;2.