

## **Multi-site Testing With a Point-of-Care Nerve Conduction Device Can Be Used in an Algorithm to Diagnose Diabetic Sensorimotor Polyneuropathy**

B.A. Perkins MD MPH,<sup>1</sup> Andrej Orszag MD,<sup>1</sup> J. Grewal MD,<sup>2</sup> E. Ng MD,<sup>2</sup> M. Ngo RRT,<sup>2</sup> and  
V. Bril MD.<sup>2</sup>

Divisions of <sup>1</sup>Endocrinology and <sup>2</sup>Neurology, University Health Network,  
University of Toronto, Canada.

### **Correspondence:**

Bruce A. Perkins  
200 Elizabeth Street, EN-12-217  
Toronto, Ontario M5G 2C4  
bruce.perkins@uhn.on.ca

Received for publication 28 June 2007 and accepted in revised form 1 December 2007.

## ABSTRACT

*Objective:* We aimed to establish whether multi-nerve testing with a point-of-care nerve conduction device could be used to diagnose diabetic sensorimotor polyneuropathy.

*Research Design and Methods:* Seventy-two consecutive patients with diabetes mellitus underwent a full neurological examination and concurrent evaluation for nine standard electrophysiological parameters using conventional nerve conduction studies (the reference standard) and a point-of-care device.

*Results:* Spearman coefficients for correlation of point-of-care and conventional parameters ranged between 0.76 and 0.91 ( $p < 0.001$  in all comparisons). Agreement by the method of Bland and Altman was acceptable despite small systematic biases. Fifty subjects (69%) had neuropathy according to conventional criteria. The sensitivity and specificity for the point-of-care device to identify such neuropathy was 88% and 82%, respectively.

*Conclusion:* A novel point-of-care device has reasonable diagnostic accuracy – and thus may represent a sufficiently accurate alternative - for detecting the diffuse electrophysiological criteria necessary to make the diagnosis of diabetic sensorimotor polyneuropathy.

Universal nerve conduction study testing for suspected neuropathy is not feasible due to limitations in availability of specialized laboratories.(1,2,3) Simplified automated devices usable by non-technicians have been developed and validated for conditions other than diabetic sensorimotor polyneuropathy (4-6). As such, we aimed to evaluate agreement and accuracy for such neuropathy by a point-of-care device.

## RESEARCH DESIGN AND METHODS

Seventy-two consecutive patients attending the Diabetes and Diabetic Neuropathy Clinic were identified and categorized for diabetic sensorimotor polyneuropathy using a clinical examination and conventional nerve conduction studies. Standardized procedures with the Counterpoint device (Medtronic, Mississauga, Canada) were used to measure conduction according to the standards of the American Association for Neuromuscular and Electrodiagnostic Medicine. Based on the American Academy of Neurology criteria, classification of neuropathy was based on the presence of at least one neuropathic symptom or sign together with electrophysiological polyneuropathy as defined by abnormality of  $\geq 2$  parameters in  $\geq 2$  nerves.(7)

The point-of-care nerve conduction studies were performed using the NC-stat<sup>®</sup> system (Neurometrix, USA), designed to perform standard non-invasive nerve conduction studies by non-technical personnel. Recently described, (8) this system consists of single-use flexible biosensor panels, a monitor, docking station, and remote on-call information system. Repeatability is comparable to conventional methods. (9)

We could predict *a priori* that the point-of-care system has minor technical limitations that interfere with its agreement with conventional studies. First, the device automatically zeros sensory nerve amplitude

potential signals below 2.1 microvolts.(8,10) Second, the point-of-care system's median motor nerve distal amplitude potential measurement is based on a 'volume conduction montage' in which the sensing electrodes are not situated directly over muscle and therefore the amplitudes are attenuated five to ten-fold. This discrepancy was viewed as a clear limitation and this parameter was not considered for analysis. The remaining nine parameters were considered sufficient to evaluate for diffuse nerve dysfunction.

Statistical analyses were performed in SAS Version 8.02 for Windows (SAS Institute, Cary, North Carolina, USA). Correlation was analyzed using Spearman's coefficients. Agreement was assessed by the method of Bland and Altman for all nine parameters.(11,12)

## RESULTS

Of the 72 patients enrolled in the study, 89% had type 2 diabetes, and mean age and diabetes duration were  $56 \pm 11$  and  $12 \pm 10$  years, respectively. In total, fifty(69%) met the diagnostic criteria for the presence of neuropathy.

Correlation between conventional and point-of-care nerve conduction studies was very high for all the parameters (Table 1). Examination of plotted regression lines (not shown) demonstrated that a degree of bias exists for all parameters. For example, examination of the plot for the median nerve distal motor latency revealed that most points were situated above the line of unity - thus, on average; the point-of-care value overestimated the conventional nerve conduction value. The degree of such *overestimation* was +0.36 milliseconds. The 3<sup>rd</sup> column of Table 1 summarizes the average bias for each parameter. To further explore the variability in systematic bias, the statistical method of Bland and Altman was

performed (represented in the 4<sup>th</sup> and 5<sup>th</sup> columns). The first of these two columns shows the upper and lower critical values for the 95% distribution of differences between values. For example, for the median nerve motor latency 95% of values fall within a range of differences as low as -0.26 millisecond and as high as +0.98. Most parameters fell within  $\pm 30\%$  of the conventional values; however there are exceptions – particularly for measurements that are low in magnitude and higher in variability.

To determine if the magnitude of bias in these measurements is of clinical significance, we aimed to determine if the diagnosis of neuropathy would differ significantly if the point-of-care values were used in place of the conventional nerve conduction study values in the diagnostic algorithm. Of the 50 individuals with neuropathy, 44 individuals were classified appropriately using the point-of care system, indicating a sensitivity of 88%. Of the 22 free of neuropathy, 18 were classified appropriately by the point-of-care system, indicating a specificity of 82%. The 10 misclassified subjects had minor electrophysiological abnormality.

## **DISCUSSION**

This study demonstrates that a point-of-care device can measure the majority of nerve conduction parameters with reasonable levels of agreement. It can accomplish this through the use of non-technologist staff in a non-specialized clinical setting. Furthermore, when all parameters are integrated along with an assessment of signs and symptoms in a diagnostic algorithm for diabetic sensorimotor polyneuropathy, the bias does not appear to be of clinical importance owing to the

sufficient sensitivity and specificity of the device. Despite meeting diagnostic criteria, subjects who were misclassified by the point-of-care system had minor degrees of neuropathy.

The results of this study imply that an unequivocal diagnosis of neuropathy may be feasible in the primary care or diabetes clinic in place of a specialized neurodiagnostic lab. However, a few limitations must be considered. First, a degree of clinical interpretation is still necessary – to what extent this interpretation is made by the remote on-call system or by the examining health care provider remains to be determined. As such, further study is required into a specific clinical protocol for the point-of-care device and, in particular, further research into investigation of patients with atypical presentations of neuropathy must be pursued. Secondly, there are technical limitations of the point-of-care system that make interpretation of certain parameters difficult, though this does not seem to interfere with diagnostic accuracy.

Application of this technology in routine diabetes care – particularly given the short turn-around time between testing and receipt of an interpretation - is a promising contribution to efficient, patient-centered care.(13,14) However, studies that investigate the implications of false-positive and false-negative results and their impact on cost-effectiveness are needed prior to widespread application of the technology.

## **ACKNOWLEDGEMENTS**

An unrestricted educational grant from Neurometrix, Inc. was used to support this investigator-driven research.

## REFERENCES

1. Herman WH, Kennedy L: Underdiagnosis of peripheral neuropathy in type 2 diabetes. *Diabetes Care* 28:1480-1481, 2005
2. Ramsey SD, Newton K, Blough D, McCulloch DK, Sandhu N, Wagner EH: Patient-level estimates of the cost of complications in diabetes in a managed-care population. *Pharmacoeconomics* 16:285-295, 1999
3. Boulton AJ, Vileikyte L, Ragnarson-Tennvall G, Apelqvist J: The global burden of diabetic foot disease. *Lancet* 366:1719-1724, 2005
4. Wells MD, Meyer AP, Emley M, Kong X, Sanchez R, Gozani SN: Detection of lumbosacral nerve root compression with a novel composite nerve conduction measurement. *Spine* 27:2811-2819, 2002
5. Kong X, Gozani SN, Hayes MT, Weinberg DH: NC-stat sensory nerve conduction studies in the median and ulnar nerves of symptomatic patients. *Clin Neurophysiol* 117:405-413, 2006
6. Vinik AI, Emley MS, Megerian JT, Gozani SN: Median and ulnar nerve conduction measurements in patients with symptoms of diabetic peripheral neuropathy using the NC-stat system. *Diabetes Technol Ther*. 2004 Dec;6(6):816-24.
7. England JD, Gronseth GS, Franklin G, Miller RG, Asbury AK, Carter GT, Cohen JA, Fisher MA, Howard JF, Kinsella LJ, Latov N, Lewis RA, Low PA, Sumner AJ: Distal symmetric polyneuropathy: a definition for clinical research: report of the American Academy of Neurology, the American Association of Electrodiagnostic Medicine, and the American Academy of Physical Medicine and Rehabilitation. *Neurology* 64:199-207, 2005
8. Perkins BA, Grewal J, Ng E, Ngo M, Bril V: Validation of a novel point-of care nerve conduction device for the detection of diabetic sensorimotor polyneuropathy. *Diabetes Care* 2:2023-2027, 2006.
9. Kong X, Lesser EA, Megerian JT, Gozani SN: Repeatability of nerve conduction measurements using automation. *J Clin Monit Comput* 6:405-410, 2006
10. Jabre JF, Salzsieder BT, Gnemi KE: Criterion validity of the NC-stat automated nerve conduction measurement instrument. *Physiol Meas* 1:95-104, 2007
11. Bland JM, Altman DG: Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet* 1:307-310, 1986
12. Bland JM, Altman DG: Comparing methods of measurement: why plotting difference against standard method is misleading. *Lancet* 346:1085-1087, 1995
13. Lesser EA, Starr J, Kong X, Megerian JT, Gozani SN: Point-of-service nerve conduction studies: an example of industry-driven disruptive innovation in health care. *Perspect Biol Med*. 2007 Winter;50(1):40-53.
14. Megerian JT, Kong X, Gozani SN: Utility of nerve conduction studies for carpal tunnel syndrome by family medicine, primary care, and internal medicine physicians. *J Am Board Fam Med*. 2007 Jan-Feb;20(1):60-4.

**TABLE 1.** Correlation and Agreement (According to the Method of Bland and Altman ) Between The Point-Of-Care and Conventional Nerve Conduction Studies in the 72 Subjects with Diabetes.

Parameter	Spearman Correlation Coeff <sup>†</sup>	Systematic Bias*		
		Mean Bias	95% CI (IN UNITS OF MEASUREMENT)	95%CI (PERCENTAGE OF CONVENTIONAL NERVE CONDUCTION VALUE)
Median				
Motor Latency	0.83	+0.36 ms	[-0.26, +0.98 ms]	[-8%, +28%]
Motor F-wave Latency	0.76	+0.29 ms	[-5.24, +5.82 ms]	[-22%, +20%]
Sensory Amplitude	0.90	- 5.89 $\mu$ V	[-25.16, +13.37 $\mu$ V]	[-62%, +5%]
Sensory Latency	0.83	+0.43 ms	[-0.75, +1.61 ms]	[-5%, +34%]
Peroneal				
Motor Amplitude	0.83	-1.16 mV	[-4.50, +2.19 mV]	[-85%, +43%]
Motor Latency	0.83	-0.42 ms	[-2.02, +1.19 ms]	[-30%, +17%]
Motor F-wave Latency	0.86	+0.74 ms	[-6.55, +8.02 ms]	[-18%, +11%]
Sural				
Sensory Amplitude	0.91	-1.55 $\mu$ V	[-5.41, +2.31 $\mu$ V]	[-100%, +33%]
Sensory Latency	0.87	-0.93 ms	[-1.63, -0.22 ms]	[-31%, -8%]

All parameters are measured at the distal point of the limb.

Data for median motor distal amplitude measurements not included owing to the technical limitations of the point-of-care system for measuring this parameter (See RESEARCH DESIGN AND METHODS).

\* Bias is calculated as a Point-Of-Care Nerve Conduction value minus Conventional Nerve Conduction value

† All Spearman coefficients have  $p < 0.0001$