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Predicting Nerve Root Pathology With Voltage-actuated Sensory Nerve Conduction Threshold

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Citation

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Abstract

Voltage-actuated sensory nerve conduction threshold (V-sNCT) is a quantitative test of sensory function. This study compares the sensitivity, specificity, and predictive value of V-sNCT compared to physical examination for the presence of nerve-root adhesions visible on epidurogram. Predicted abnormal nerve roots by V-sNCT and/or physical examination were compared with abnormal nerve roots documented by abnormal epidurogram in forty-nine patients with L5/S1 radicular back pain. Sensitivity, specificity, and predictive value for V-sNCT predicting nerve root pathology were 94.6%, 70.2%, and 91.0%, respectively, compared to 61.7%, 72.3%, and 87.6%, respectively, for prediction by physical examination alone. In addition, area under ROC Curve and relative risk for V-sNCT were significantly more predictive of nerve-root pathology than physical examination ($p<0.05$). Prediction of abnormal nerve-root pathology with V-sNCT is superior to prediction from neurological examination.

INTRODUCTION

Sensory neurological examination is an important part of any physical examination. This part of the physical examination takes on even more importance in the workup of the patient with chronic pain. During World War II, Dr. George Riddoch, a neurologist in the British Army, developed a logical approach to the sensory examination with the concept of identifying “signature” surface areas highly correlated with specific anatomic dermatomes, which, in turn, are associated with specific nerve roots.[1] Later, the concept of current perception threshold (CPT) was developed to quantitate level of sensory deficit.[2] Problems developed with this diagnostic technique, however, with significant variability associated with changing skin resistance.[3] Recently, the concept of voltage-actuated sensory nerve conduction (V-sNCT) has resulted in the development of a new instrument to quantitate sensory function (Medi-Dx 7000, Neuro-Diagnotic Associates, Inc., Laguna Beach, CA). This instrument provides testing which is voltage mediated, and results are independent of changes in skin resistance. The purpose of this study was to assess how well V-sNCT worked in predicting nerve root pathology as defined by filling defects on epidurogram prior to epidural lysis of adhesions.

METHODS

After IRB approval and informed consent, patients with L5 or S1 radicular back pain scheduled for lysis of epidural adhesions[4] were studied. All patients underwent pre-procedure V-sNCT testing. All patients received catheter-directed lysis of adhesions, during which an epidurogram was done with 10 ml of Omnipaque-180 contrast. Predicted abnormal nerve roots identified by V-sNCT prior to the procedure were compared with abnormal nerve roots documented by abnormal epidurography of the nerve root. In addition, neurological examinations were conducted relating to the nerve roots tested. Neurological examination for L5 and S1 nerve roots were conducted as described by Hoppenfeld.[5] Neurological exam associated with L5 and S1 consisted of a motor, reflex (except for L5), and sensory test. Motor test for L5 was to test dorsiflexion of the big toe with the extensor hallucis longus. The examiner supported the patient's foot with one hand around the calcaneus and then placed his/her thumb in such a position that the patient must dorsifex his/her great toe to reach it. The examiner opposed the dorsiflexion by placing his/her thumb on the nail bed of the great toe and fingers on the ball of the foot. Motor test for S1 was to test plantar flexion and eversion of the foot by opposing this motion with pressure on the head of the fifth metatarsal. There is no reflex to test for L5 function, but S1 was tested with the Achilles tendon reflex. Sensation for L5 was tested on the dorsum of the foot; sensation for S1 was tested at the lateral malleolus. In addition to the L5 and S1 nerve roots, major peripheral nerves tested included the

superior and inferior gluteal nerves, as well as the sciatic, tibial and common peroneal nerves.

The statistical analysis tested the predictive power of V-sNCT compared to the predictive power of physical examination, using the abnormal epidurogram as the pathological standard. Analysis was with chi-square and ROC analysis,[6] with significance defined at $p<0.05$. Sensitivity, specificity, and predictive value for V-sNCT and physical findings as predictors of root pathology were calculated using the following formulas:6

Confidence intervals of the areas under the ROC curves were used to test for significant difference between prediction with V-sNCT and neurological examination at $p<0.05$. Also, relative risk and 95% confidence intervals were calculated for abnormal epidurogram, given an abnormal V-sNCT or an abnormal neurological examination at L5 and S1. Visual analog scores (VAS) were compared using Student's paired t-test. Significance was $p<0.05$.

RESULTS

Forty-nine patients were studied, 28 males and 21 females. Age (mean±SEM) was 49±2, weight 86±3 kg, height 172±1 cm. Twenty-five patients had undergone previous back surgery; all had a diagnosis of lumbar radiculitis. VAS pain scores prior to procedure were 8.6±0.2 and one month after the procedure VAS pain scores were 4.4±0.4 ($p<0.05$). V-sNCT test results and epidurograms for a patient with an S1 lesion are shown in Figure 1 and Figure 2. Sensitivity, specificity, and predictive value for V-sNCT predicting nerve root pathology were 94.6%, 70.2%, and 91.0%, respectively, and an ROC curve was calculated (see Figure 3). Area under the ROC curve is 0.82 0.04 ($p<0.001$; 95% CI 0.76-0.90) for V-sNCT, compared to 0.67 0.04; 95% CI 0.60-0.74) for neurological examination ($p<0.05$).

Figure 1

Figure 1. V-sNCT and epidurogram prior to lysis of adhesions at S1. Note hypoesthesia of right S1 on the V-sNCT graph is correlated with lack of filling of the right S1 nerve root on epidurogram. Left is left and right is right on epidurogram.

Figure 2

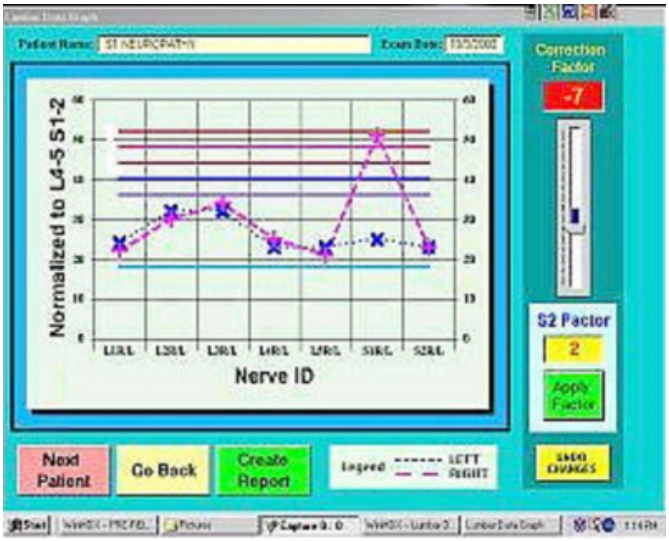


Figure 3

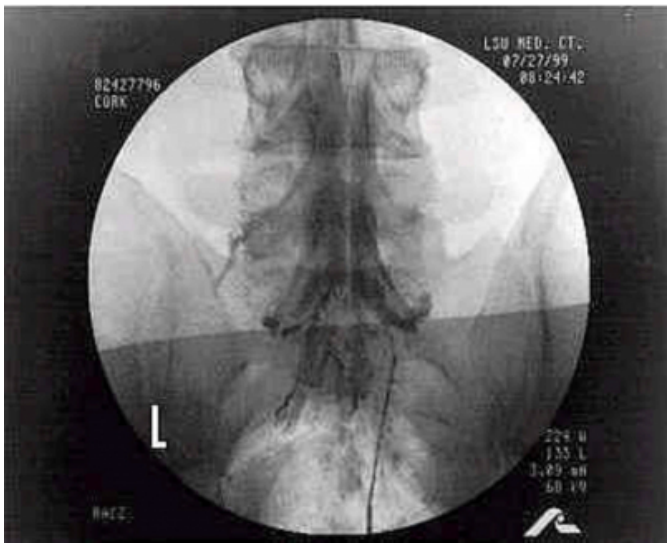


Figure 4

Figure 2. V-sNCT and epidurogram after lysis of adhesions at S1. Note that V-sNCT is returned to normal and right S1 nerve root now fills with contrast.

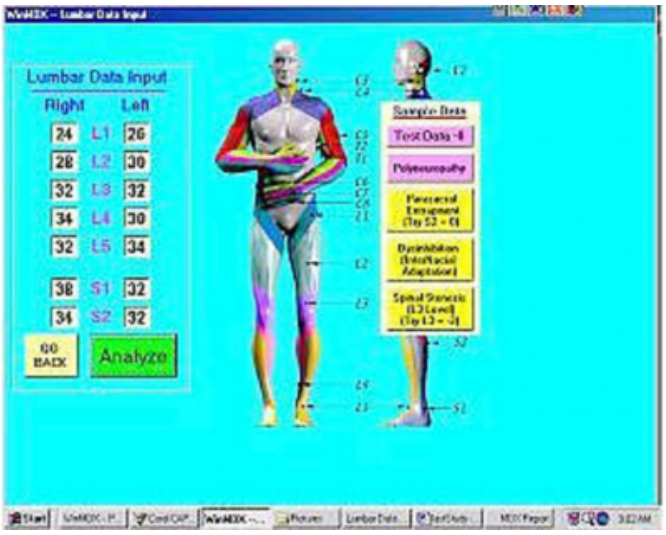


Figure 5

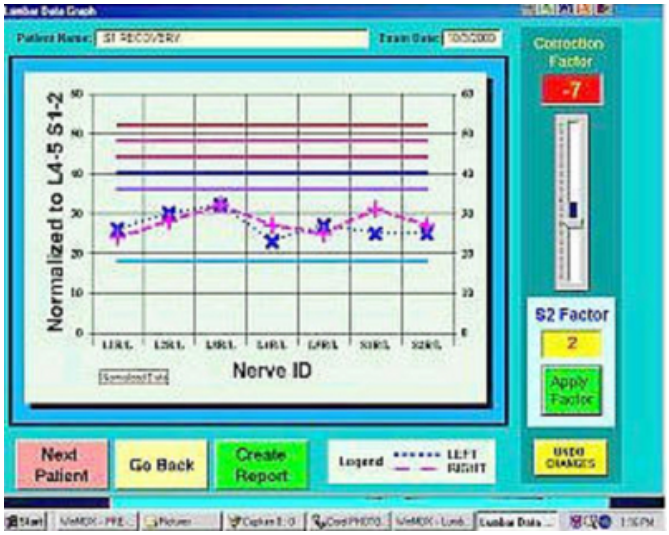


Figure 6

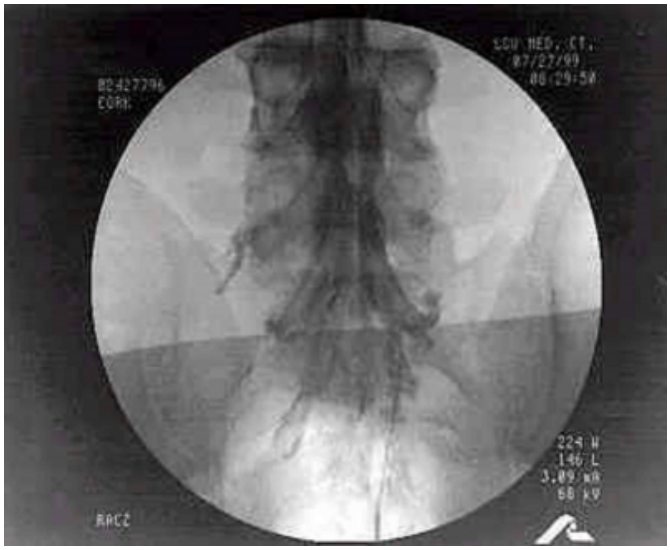
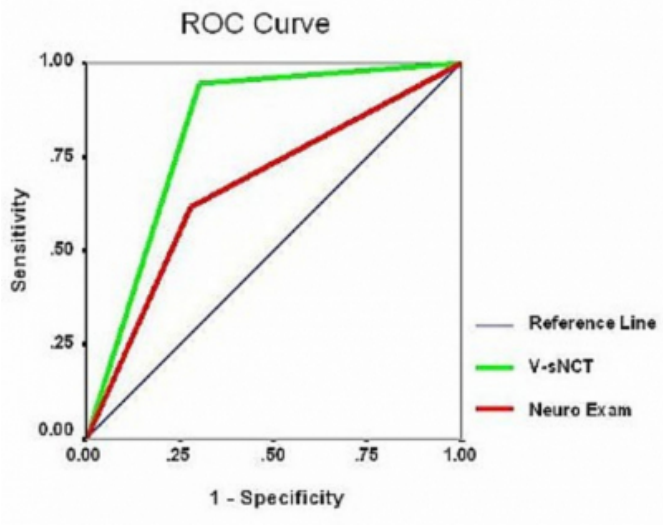


Figure 7

Figure 3. Receiver Operating Characteristic (ROC) curves comparing the effectiveness of V-sNCT and neurological examination in predicting nerve root pathology. Better predictors are indicated with movement of the reference line to the upper left.



Results for all nerve roots tested are displayed in Figure 4 for V-sNCT and Figure 5 for the neurological examination. Sensitivity, specificity, and predictive value were 61.7%, 72.3%, and 87.6%, respectively, for prediction of abnormal epidurogram by physical examination alone.

Finally, relative risk (with 95% confidence interval) of abnormal epidurogram, given an abnormal V-sNCT is 4.67 (2.50-8.69), compared to 1.40 (1.17-1.66) given an abnormal neurological examination. These data are summarized in the following table 1:

Figure 8

Figure 4. Prediction of nerve root pathology by V-sNCT. Abnormal and normal nerve roots can be predicted by V-sNCT (p

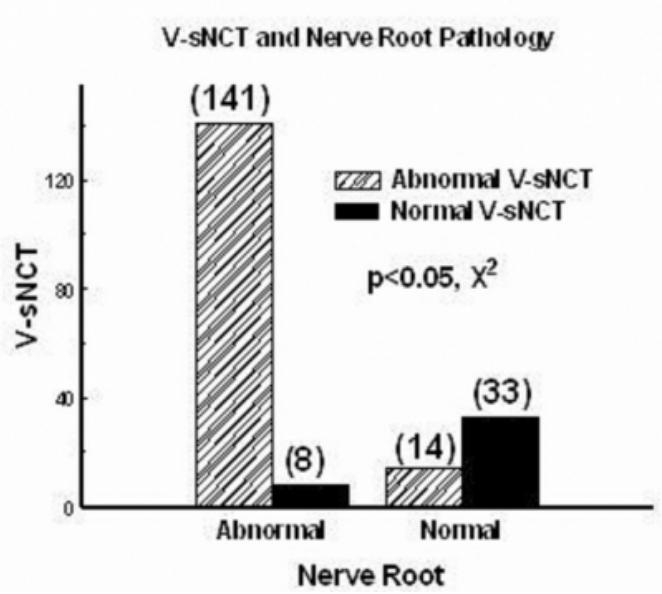


Figure 9

Figure 5. Prediction of nerve root pathology by neurological examination. Abnormal and normal nerve roots can be predicted by neurological examination (p

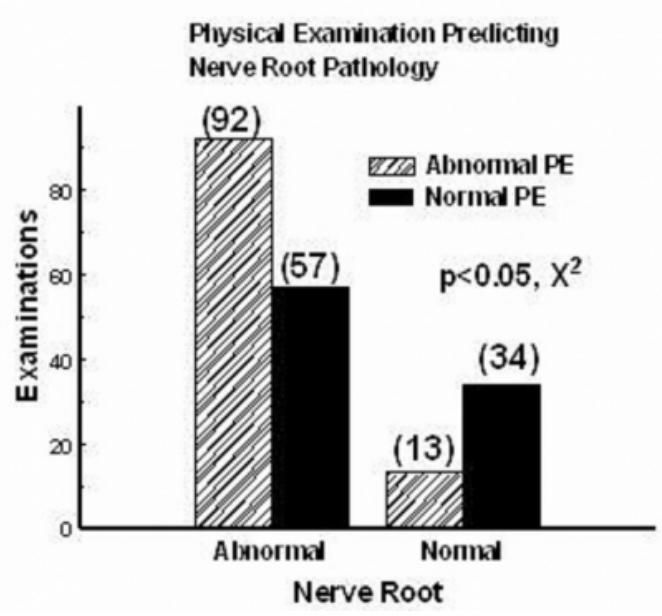


Figure 10

Table: Comparison of Predictors of Pathology

	V-sNCT	Neurological Examination
Sensitivity	94.6%	61.7%
Specificity	70.2%	72.3%
Predictive Value	91.0%	87.6%
Area under Curve (ROC)	0.82±0.04 (0.76-0.90)*	0.67±0.04 (0.60-0.74)
Relative Risk	4.67 (2.50-8.69)*	1.40 (1.17-1.66)

*p<0.05, compared to Neurological Examination.

DISCUSSION

Voltage-actuated sensory nerve conduction threshold (V-sNCT) is a direct quantitative sensory test which provides a reproducible functional assessment of the peripheral sensory nervous system by measuring that voltage intensity which initiates membrane potential changes to propagate nerve impulses. This study used the Medi-Dx 7000 to test the V-sNCT. A predecessor, the Neurometer assesses sensory function by measuring current output, which varies with changes in skin resistance. Although sensitivity with V-sNCT was superior to neurological examination, specificity was no different than the neurological examination. However, both the V-sNCT and neurological examination give the clinician the ability to test various branches of the peripheral nerves, which may result in further definition of the location of entrapment/pathology to specific nerve segments.

CONCLUSION

The purpose of this study was to compare the sensitivity and specificity of V-sNCT for the presence of nerve-root adhesions visible on epidurogram. Voltage-actuated sensory nerve conduction threshold provides the pain-management specialist with a sensitive and specific tool for prediction of nerve root pathology. Advantages of V-sNCT include simplicity, decreased test time, small intra-patient variability, and decreased sensitivity to changes in skin resistance. It is a better predictive test than the neurological examination because it is a more sensitive test. In addition, because the patient is blinded to the V-sNCT results, it may be a very good test for malingering. This study demonstrates that prediction of nerve-root pathology with V-sNCT is superior to prediction of nerve-root pathology from neurological exam alone.

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