Published in final edited form as:

JAMA. 2016 January 19; 315(3): 297–298. doi:10.1001/jama.2015.16832.

Electrodiagnostic tests in polyneuropathy and radiculopathy

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Case presentation

A 66 year old man with a history of mild diabetes (2 years), coronary artery disease and gout presented to the neuromuscular clinic with tingling and weakness in his legs. He first noted tingling in his feet 2–3 years ago, which slowly progressed to involve his whole foot with numbness that spread up to his knees. Over the same time, he noted trouble with his balance, describing that he is “standing on a cushion”. He had low back pain for years, but starting one year ago he started to hunch over all the time as the result of increasing back pain. He was only able to walk 200–300 yards before back and leg pain became limiting. Standing did not relieve the pain, but sitting did. If he walked for a few minutes, he felt like he ran a marathon with extreme muscle fatigue. He also experienced occasional warm numbness down both legs, left worse than right, sometimes radiating down the back of his legs and other times into his groin. Neurologic examination revealed strength (R/L) 4+/4 dorsiflexion, 5/4+ plantarflexion, otherwise 5/5 throughout. Vibration sensation was (R/L) 0/2 seconds at the toes and pinprick sensation was decreased to the ankles bilaterally. Reflexes were 2+ throughout with the exception of absent ankle jerks. He was unable to toe or heel walk, worse on the left. Given the diagnostic uncertainty of the localization of nerve injury, electrodiagnostic testing was performed. These tests revealed normal sural sensory responses, asymmetric tibial and peroneal motor amplitudes (worse on the left), and active denervation with chronic reinnervation in right L5/S1 innervated muscles including lumbosacral paraspinal muscles.

What is the main cause of his lower extremity symptoms based on the interpretation of these test results?

A. Mononeuritis multiplex

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Disclosures:

Dr. Callaghan receives research support from Impeto Medical Inc. and honorarium from the British Medical Journal. He certifies ALS centers for the ALS Association, performs medical consultations for Advance Medical, and consults for a PCORI grant. Dr. Burke has received compensation from Astra Zeneca for his role on the adjudication committee of the SOCRATES trial, honoraria from the AAN for contributing to the Continuum series and consulting fees from Sullivan, Ward, Asher and Paton for reviewing case materials in a medical malpractice defense case. Dr. Feldman reports no disclosures. Dr. Burke has received compensation from Astra Zeneca for his role on the adjudication committee of the SOCRATES trial, honoraria from the AAN for contributing to the Continuum series and consulting fees from Sullivan, Ward, Asher and Paton for reviewing case materials in a medical malpractice defense case.

- B. Polyneuropathy
- C. Radiculopathy
- D. Vascular claudication

Answer

- C Radiculopathy

Test characteristics

Electrodiagnostic tests include nerve conduction studies and electromyography. No consensus exists for the sensitivity and specificity of nerve conduction studies for the detection of polyneuropathy with many different criteria proposed.¹ Moreover, the lack of a gold standard makes definitive assessment of these parameters difficult. Further complicating matters in this patient is that radiculopathy and polyneuropathy can both affect motor responses, whereas only polyneuropathy affects sensory responses. Therefore, the sural sensory response amplitude is the most important parameter obtained. A reasonable estimate of the diagnostic characteristics of this test is a sensitivity of 66% and a specificity of 93% for the detection of polyneuropathy.² One reason the specificity is not higher is that the sural amplitude can rarely be reduced in patients with radiculopathy. This equates to a positive likelihood ratio (LR) of 9.4 and a negative LR of 0.37. Similarly, the best test to evaluate whether a radiculopathy is present is the electromyography, with a sensitivity of 46% and a specificity of 88%.³⁻⁵ This equates to a LR of 3.7 and a negative LR of 0.62. The Medicare cost for nerve conduction studies depends on the number of nerves studied (ranges from \$97.97 for 1–2 nerves to \$297.84 for 13+ nerves), with the 10 nerves performed in this study costing \$235.62. Electromyography of one complete limb costs \$91.89.

Application of test result to this patient

In order to use the LRs for these tests, clinicians must first know the pre-test probability that our patient has a polyneuropathy or radiculopathy. Given the prevalence of polyneuropathy in those with diabetes and the prevalence of radiculopathy in the general population, the pretest probability before additional history is likely 80% for polyneuropathy and 20% for radiculopathy.^{6,7} In light of historical factors favoring radiculopathy such as leg pain worse with walking and relieved with sitting, chronic low back pain, hunching over when walking, and asymmetric weakness, a reasonable estimate is a pre-test probability of 60% for polyneuropathy and 40% for radiculopathy. Given the positive electromyography test (positive LR of 3.7), the post-test probability that our patient has a radiculopathy is 71%. In contrast, the normal sural amplitude (negative LR of 0.37) changes the post-test probability of polyneuropathy to 36%. While he still may have a mild diabetic polyneuropathy, this is unlikely the main contributing cause of his lower extremity symptoms, especially when considering the severity of his examination. Since the electrodiagnostic tests were highly suggestive of radiculopathy and not polyneuropathy, the next test ordered was a lumbar MRI. This study revealed severe central canal stenosis at L4/5 with compression of bilateral L4, right L5, and left S1 nerve roots further increasing the probability of radiculopathy. Central canal stenosis can cause compression of all nerve roots at or below the level of the

narrowing. Compression of the bilateral L4 and L5 nerves explains the patient's bilateral dorsiflexion weakness and the left S1 nerve compression explains the left plantarflexion weakness. This case illustrates the utility of electrodiagnostic tests in distinguishing between radiculopathy and polyneuropathy with an eventual diagnosis of lumbar stenosis. However, it should be noted that lumbar stenosis does not typically present with weakness, routinely require electrodiagnostic tests, or typically require surgery.

What are alternative diagnostic testing approaches?

An alternative approach would have been to obtain a lumbar MRI first, but the downsides of this approach are twofold. First, lumbar MRI is unable to evaluate the presence of a polyneuropathy or the combination of a polyneuropathy and radiculopathy. Second, lumbar MRI studies frequently reveal abnormalities that do not cause patient symptoms.^{8,9}

Patient outcome

The patient had a L4-5 laminectomy and discectomy. One year after surgery, his walking improved from only 200–300 yards to 1.5 miles. He no longer has low back pain, pain into his groin, or warm numbness radiating into his legs. He no longer has to grab onto objects for balance and is not hunched over at the end of the day. He still has numbness below his knees and tingling in his feet, which has only slightly improved. Neurologic examination revealed improved dorsiflexion strength, but plantarflexion strength remained unchanged. Vibration sensation improved slightly.

Acknowledgments

All authors contributed equally to the preparation of content, writing, and revision of the manuscript. Funding support during the preparation of this article was provided by the National Institutes of Health (DP3 DK094292 and R24 DK082841 to E.L.F.; K23 NS079417-01 to B.C.C.), the American Diabetes Association (to E.L.F.), and the A. Alfred Taubman Medical Research Institute (to E.L.F.). The authors have nothing to disclose.

Study Funding:

Drs. Callaghan and Feldman are supported by the Katherine Rayner Program and by the Taubman Medical Institute. Dr. Callaghan is supported by a NIH K23 grant (NS079417). Dr. Burke is supported by NINDS K08 NS082597 and R01 MD008879. Dr. Feldman is supported by NIDDK DP3DK094292 and R24 082841. The study sponsors had no role in the preparation, review, approval of the manuscript, or decision to submit the manuscript for publication.

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Clinical Bottom Line

- Electrodiagnostic tests are particularly helpful when the localization of the pathology is unclear, such as when features of polyneuropathy (length dependent sensory symptoms and examination features) and radiculopathy (back pain with radiation of symptoms into the legs and asymmetric weakness) are both present.
- Electromyography has good specificity (88%) but low sensitivity (46%) for the detection of a radiculopathy. Electromyography has a particularly low sensitivity for the detection of a sensory predominant radiculopathy.
- The sural amplitude is the best electrodiagnostic parameter to distinguish between a polyneuropathy and radiculopathy.
- Lumbar MRI is unable to distinguish between a polyneuropathy and radiculopathy and has a high false positive rate.

Table 1

Nerve conduction and electromyography results

Nerve	Amplitude (mV or uV) *	Latency (ms)	Conduction velocity (m/s)
Right sural sensory	8.0 (>=6.0)	3.4 (<4.2)	48.3 (>=41.0)
Left sural sensory	6.8 (>=6.0)	3.6 (<4.2)	50.0 (>=41.0)
Right peroneal motor	NR (>=2.0)	NR (<6.1)	NR (>=41.0)
Left peroneal motor	0.9 (>=2.0) 0.5 (>=2.0)	4.1 (<6.1) 12.4	38.8 (>=41.0)
Right tibial motor	2.6 (>=3.0)	4.8 (<6.1)	
Left tibial motor	0.4 (>=3.0)	5.5 (<6.1)	
Muscle (right lower extremity)	Abnormal spontaneous activity	Recruitment	Motor unit morphology
Lateral gastrocnemius	Yes	Neurogenic	Neurogenic
Anterior tibialis	Yes	Neurogenic	Neurogenic
Gluteus medius	Yes	Neurogenic	Neurogenic
Gluteus minimus	Yes	Neurogenic	Neurogenic
Internal hamstring	Yes	Neurogenic	Neurogenic
Vastus Medialis	No	Normal	Normal
Low lumbar paraspinal	Yes		

* Amplitude is in mV for motor responses and uV for sensory responses NR= no response

Abnormal nerve conduction study values are bolded