EMG/NCS in the evaluation of spine trauma with radicular symptoms

James A. Charles, MD, FAAN

Nizar Souayah, MD

Summary

In the management of spine trauma with radicular symptoms (STRS), EMG/nerve conduction studies (NCS) often have low combined sensitivity and specificity in confirming root injury. The anatomic level of injury may not correspond to the root level. Paraspinal studies are nonlocalizing and can be falsely positive and negative. Unlike MRI and CT imaging, EMG/NCS do not reveal the biological morphology of the lesion. There are no studies that confirm the efficacy of EMG/NCS in the management of STRS. EMG/NCS may be indicated if there is a differential diagnosis between a root and distal neuropathic/myopathic lesion. Otherwise, as shown in this series of cases typically referred for outpatient EMG/NCS testing, there is limited evidence to support the use of often uncomfortable and costly EMG/NCS in STRS.

EMG/nerve conduction studies (NCS) is an extension of the neurologic clinical evaluation focusing on the peripheral nervous system, and recognizing that lesions do not occur in electrodiagnostic isolation, but are to be taken in coordination with a thorough neurologic examination and imaging studies to assess the patient's clinical picture. Many referrals to the electrodiagnostic laboratory are for nonmyelopathic traumatic injuries to the spine region causing axial, referred, and radicular signs and symptoms. History, examination, and imaging are essential elements of the diagnosis and treatment algorithm. Lumbosacral and cervical trauma can cause non-neural axial or referred symptoms due to injuries to the paraspinal muscles, ligaments, sacroiliac and zygapophysial joints, and peripheral disk annulus. Herniated disks (HNP), fractures, spondylolisthesis, and exacerbation of preexisting spondylosis/spondylolisthesis

Department of Neurosciences, New Jersey Medical School, Newark.

Correspondence to: jacharlesmd@gmail.com

can lead to radicular, referred, or myelopathic findings.¹ Using a series of representative cases of patients with spinal, nonmyelopathic trauma, we review the role of EMG/NCS in conjunction with review of the literature in patients referred for outpatient electrodiagnostic studies.

This correspondence on the use of outpatient EMG/NCS is limited to cervical and lumbosacral spine trauma with radicular symptoms (STRS) without myelopathy; not inflammatory, infectious, or hereditary causes. Typical injuries with STRS include motor vehicle accidents, sports injuries, slip and falls, and heavy pulling or pushing. Traumatic myelopathies often present in the emergency department or are diagnosed by history, examination, and MRI without EMG/NCS, which assesses the peripheral nervous system. We also excluded traumatic thoracic radiculopathies as they are rare, accounting for less than 2% of all traumatic and nontraumatic radiculopathies. EMG/NCS are not commonly used in the evaluation of thoracic myelopathy or radiculopathy.² Anterior rami testing of abdominal muscle and thoracic paraspinal muscle needle EMG testing is hazardous and does not yield specific myotomal information.³

Case Report 1: EMG/NCS for differential diagnosis

A 63-year-old obese right-handed man injures his neck in a motor vehicle accident causing neck pain down the right shoulder with a normal neurologic examination except for limitation of cervical rotation and paraspinal tenderness. MRI reveals multilevel disc ridge complexes and neural foraminal stenosis without cord compression. Six months later, the patient complains of numbness, early morning paresthesias, and weakness in the right radial hand. Examination now demonstrates bilateral Tinel sign, decreased pin sensation right thumb and index finger, and slight weakness right abductor pollicis brevis (APB). EMG/NCS revealed prolonged right median motor and sensory distal latencies and +2 fibrillations and decreased recruitment in the right APB. Few fibrillation and positive sharp wave (PSW) potentials were found in the bilateral cervical paraspinals and prolonged left (asymptomatic) median sensory distal latency. Right C6 myotomal EMG was negative.

Discussion Although right carpal tunnel syndrome (CTS) is suspect in this case, trauma or the natural progression of cervical spondylosis can result in right C6 root irritation that may worsen over time. The initial trauma causing pain down the right shoulder with normal strength reflexes and sensation is characteristic of referred rather than radicular pain. Asymptomatic cervical spondylosis and herniations can be seen in up to 60% of patients over age 40.^{4,5} The prevalence of abnormal MRI of the cervical spine as related to age in asymptomatic individuals emphasizes the dangers of predicating operative/invasive decisions on diagnostic tests without precisely matching those findings with clinical signs and symptoms.⁴ CTS results in median nerve hand sensory symptoms overlapping the C6 dermatomal distribution. Prolonged right median motor and sensory distal latencies and fibrillations/reduced recruitment in the right APB is consistent with right CTS. Prolonged left (asymptomatic) median sensory distal latency with left Tinel sign is a predictor of incipient left CTS. Cervical paraspinal fibrillations/PSW can be seen in 12% of the asymptomatic general population, 8% of asymptomatic subjects between ages 40 and 60, and up to 90% of asymptomatic subjects over age 60.^{6,7} In this case, no right upper limb myotomal acute or chronic denervation was found except for the right APB innervated by the median nerve, which has prolonged motor and sensory distal latencies. Because electromyographic cervical paraspinal abnormalities can be found in asymptomatic subjects, caution should be exercised when attributing the etiology of neck pain to radiculopathy if the only electrodiagnostic findings are electromyographic cervical paraspinal abnormalities.⁶ Fibrillations and positive sharp waves do not have much electrodiagnostic value in the study of cervical paraspinal muscles of middle-aged and elderly subjects. When it is an isolated finding, there is a need for an extended electromyographic examination, including other muscles, to exclude radiculopathy.⁷

EMG/NCS may be required in STRS if the clinical and radiographic findings cannot clearly differentiate a radiculopathy from a nerve root avulsion, lesion distal to the neural foramen such

as a plexopathy, mononeuropathy, or polyneuropathy. A C8 radiculopathy can be mistaken for an ulnar neuropathy or thoracic outlet syndrome. Clinically, it may be impossible to distinguish an L2, L3, or L4 radiculopathy from a lumbar plexopathy or femoral neuropathy. L5 radiculopathies can be confused with common peroneal neuropathy at the fibular head with foot drop. S1 radiculopathy can be confused with a distal tibial mononeuropathy as in tarsal tunnel syndrome. Bilateral S1 radiculopathies can present with similar clinical findings found in axon loss peripheral neuropathies. Motor neuron disease can be mistaken for root lesions.³

In this case, it was concluded that the neck injury caused referred pain from cervical spondylosis, and age/obesity-related right CTS is a separate and significant problem. EMG/NCS demonstrated clinical utility in the differential diagnosis of right C6 radiculopathy vs right CTS.

Case report 2: Established diagnosis but the treating physician orders EMG/NCS to guide treatment

A 29-year-old healthy woman sustains a left L4-5 HNP from a motor vehicle accident 6 weeks ago. She complains of severe pain traveling down the left posterolateral thigh, calf, and dorsal foot with numbness in the left big toe. Examination reveals 4/5 weakness left gluteus medius, tibialis anterior and posterior, peroneus longus, extensor digitorum brevis, and extensor hallucis and + left straight leg raising maneuver at 45° and decreased sensation left dorsal lateral foot and leg. MRI left spine reveals left L4-5 HNP compressing the left L5 nerve root. The treating physician orders EMG/NCS to “guide therapy” after the patient has failed analgesics, anti-inflammatory agents, and physical therapy.

Discussion: Is there any evidence that EMG/NCS in the context of established traumatic radiculopathy will guide treatment or prognosis in STRS? In an evidence-based review on the utility of electrodiagnostic testing in evaluating patients with lumbosacral radiculopathy, the utility of EMG/NCS in prognosticating outcome or response to treatments was not addressed.⁸ In a review of EMG/NCS in clinical practice, it was noted that EMG/NCS have little prognostic value in radiculopathy when compared to clinical and psychosocial factors.⁹

Electrodiagnostic evidence of lumbar radiculopathy in symptomatic patients combined with radicular pain and physical findings consistent with lumbosacral radiculopathy can be an independent predictor of long-term improvement in pain after interlaminar lumbar epidural steroid injection (LESI). Improvements in patients with abnormal EMG/NCS can be statistically significant. However, patients with normal EMG/NCS also tend to respond favorably to LESI. Also, results of EMG/NCS cannot predict surgical outcome.^{10,11} Although these studies may suggest trends for using EMG/NCS to determine need for laminectomy or epidural injections, they are not powered to create a practice parameter or guidelines regarding treatment for a patient with a severe radiculopathy on the basis of EMG/NCS results.

When the EMG/NCS can localize a lesion to a particular root, the pathophysiology of the lesion cannot be identified, and the specific anatomical level for laminectomy, foraminotomy, or epidural injection may not correspond to the root segment, e.g., lateral vs posterolateral disk herniation.³

In this case, a follow-up MRI could demonstrate disk regression, but the EMG/NCS could show an L5 radiculopathy by spontaneous activity and reduced recruitment pattern implying progression to axonal injury rather than neuropractic injury. However, there are no data regarding predictive value of EMG on outcome in severe compressive traumatic radiculopathy confirmed by clinical evaluation or MRI regardless of EMG/NCS results. There is absence of evidence, either in the form of randomized clinical trials or large-scale outcome studies of utility of EMG/NCS in STRS. In our case of an established painful left L5 radiculopathy due to a left L4-5 HNP with myotomal weakness in a patient who has failed physical therapy, options of epidural injections or discectomy cannot be justifiably withheld or modified on the basis of EMG/NCS results.

EMG/NCS is not necessary in a clear-cut radiculopathy or in patients with isolated mechanical low back pain.

Case report 3: Question of acute and/or chronic radiculopathy and is there a clinical purpose for EMG/NCS?

A 47-year-old man in a work-related accident 10 years ago sustained a left L5-S1 herniated disk with complete resolution of a left S1 radiculopathy following physical therapy. One year ago, the patient lifted a heavy object at work resulting in pain and burning down his posterior left lower limb into his small toes. Examination is unrevealing except for positive left straight-leg-raising at 45° and a diminished left ankle reflex. MRI reveals a large left L5/S1 paracentral disk extrusion compressing the left S1 nerve root, similar to the MRI study 10 years ago. The referring physician sends the patient for EMG/NCS to rule out acute vs chronic radiculopathy. The patient has been unable to work for the past year in spite of physical therapy and 3 LESIs.

Discussion The sensitivity of EMG/NCS in known cases of lumbosacral radiculopathy can range from 49% to 95% using the gold standard of clinical assessment and imaging.¹² Compared with imaging, the false-positive rate of paraspinal mapping in 1 study is 8%, and the false-negative rate is 33%.¹³ Nardin et al.¹⁴ approximated that 42% of normal subjects, especially older patients, have fibrillations or positive sharp waves in lumbosacral paraspinal muscles. Chronically denervated myotomes may not reveal spontaneous activity and ongoing reinnervation with time may yield normal motor unit action potential (MUAP) and full recruitment patterns. MUAP polyphasia is not an indicator of chronic denervation as an isolated finding. Moreover, between 10% and 20% of MUAPs may be polyphasic in normal muscles. An unacceptably high incidence of false-positive studies results when polyphasia is used as the sole criterion of radiculopathy.³

Findings on needle EMG depend on axonal loss. If isolated preganglionic sensory root is injured causing pain and paresthesia (as in our case), the EMG will be negative. Also, given the extensive overlap in myotomes, loss of a few axons may be neither discernible nor localizable on needle EMG. Alternatively, the H reflex is specific for localization and not for quantification of the degree of S1 compression at the root level; it will often be absent in patients over 60 who also have absent ankle reflexes and can be normal or delayed in incomplete S1 root involvement even with normal ankle reflexes. F waves have no role in evaluating a radiculopathy because even a single preserved axon can effectively carry antidromic transmission. Also, there are a number of confounding variables in certain subsets of patients that may compromise the ability to isolate a radiculopathy, e.g., advanced age, diabetes mellitus, and polyneuropathy. There are no published guidelines that would deny or justify treatment of this patient if EMG/NCS were normal or revealed acute or chronic denervation.

Case report 4: Low back pain referred to the right lower limb and a herniated disk (HNP) on the left

A 30-year-old jogger has been complaining of LBP traveling down her right hip and rarely posterior thigh with standing and exertion. Examination is normal. MRI reveals a left L4-5 HNP.

Discussion In the evaluation of patients with suspected traumatic radiculopathy, one must be knowledgeable of the literature on herniated disks and stenosis in the asymptomatic population. In a large cohort of asymptomatic volunteers younger than 60 years, investigators found 22% prevalence of herniated disk and 1% neural foramina stenosis. In volunteers older than 60 years, 36% had herniated disks and 21% had stenosis.¹⁵ Clearly, this patient has axial and referred pain down the right hip with an incidental left L4-5 asymptomatic HNP. EMG/

The sensitivity of EMG/NCS in known cases of lumbosacral radiculopathy can range from 49% to 95% using the gold standard of clinical assessment and imaging.

NCV is not able to assess pain transmission or pathology in the sensory small unmyelinated C and myelinated A- δ nerve fibers responsible for nerve transmission from nociceptive extra-neural spinal and paraspinal structures which can cause axial and referred pain.³ This patient has mechanical low back pain referred to the right proximal low limb with an incidental, asymptomatic left L4-5 HNP. EMG/NCS is not necessary in a clear-cut radiculopathy or, as in this case, in patients with isolated mechanical low back pain.¹⁶

Case report 5: Spinal stenosis worsened by trauma

An 80-year-old man presents with a 1-year history of lower back and claudication type pain radiating into the lower extremities with short walks and a normal neurologic examination by history. Vascular studies of the lower limbs are normal. MRI demonstrates L4-5 severe stenosis due to thickened ligamentum flavum and bony hypertrophy. The patient falls on ice, complaining of worsening of symptoms. Follow-up neurologic examination remains normal except for lumbosacral tenderness, and follow-up MRI lumbosacral spine shows no change. EMG/NCS of both lower extremities are requested.

Discussion Spinal stenosis can be a coexisting finding in STRS. Spinal stenosis can cause radicular/clauidication symptoms, or be an incidental radiographic finding in up to 40% of asymptomatic patients over age 60.¹⁷

As in our previous case of the 29-year-old patient with a compressive left L5 radiculopathy, there is no consensus in the literature leading to an accepted algorithm utilizing EMG/NCS to guide treatment or predict prognosis. Investigators examined the outcomes of laminectomy for a group of 25 patients with spinal stenosis and a group of 25 patients with diabetes (confirmed by NCS) with lumbar spinal stenosis. The outcomes were similarly successful for most patients in both groups. The EMG/NCS assessed the differential consideration of root-level pathology vs length-dependent diabetic neuropathy, but the results of EMG/NCS testing were irrelevant in predicting outcome of spine decompression surgery.¹⁷ Finding MRI changes that correlate with electrodiagnostic abnormalities that might lead to more successful treatment decision-making in spinal stenosis was the goal of a study involving 150 subjects. Needle EMG did not differentiate patients with symptomatic mild or moderate lumbar stenosis.¹⁸

In a prospective study of EMG/NCS and MRI to predict lumbar stenosis and low back pain, imaging did not differentiate symptomatic from asymptomatic persons. Although the study concluded that the most accurate correlate with the clinical syndrome of spinal stenosis was paraspinal denervation, specificity of paraspinal fibrillations was 90% but the sensitivity was 33%. Paraspinal mapping has a sensitivity of 45.1% and a specificity of 84.1% in this population, suggesting that paraspinal mapping could differentiate symptomatic from asymptomatic cases regardless of imaging.¹⁹ However, low sensitivity and lack of data on the predictive value of EMG/NCS on outcome makes utility of EMG/NCS marginal.

As in the previous case, decisions on treatment of this patient will be predicated on the history, physical examination, and MRI with no practical utility from EMG/NCS.

CONCLUSION

Relevant studies discuss electrodiagnostic testing and methodology of nerve root function that complements information from history, examination, and imaging studies in patients with radiculopathy, and demonstrate variable sensitivities and specificities due to various timing, anatomical, and comorbidity reasons.²⁰ However, there are no practice parameters or established guidelines on the clinical utility of EMG/NCS in the evaluation of STRS. Current practice can include a systematic referral to the electrodiagnostic laboratory seeking information about neurologic complaints from STRS, and for preoperative and postoperative diagnostic and prognostic evaluations. This review suggests that such referrals, without clinical or imaging correlates, can be of low yield, notwithstanding the expense and discomfort from testing. It appears that unless there is a clinical differential diagnosis including a peripheral neuropathic/myopathic lesion vs a root lesion that cannot be resolved with the history, neurologic examination, and imaging studies, there is limited evidence to support the use of EMG/NCS in the evaluation, treatment, and prognosis of patients with spine trauma with radicular symptoms. Most study sample sizes are small, nonrandomized, or inadequately powered to assess improved outcomes from EMG/NCS studies. Better evidence for utility of EMG/NCS in STRS is required in the form of randomized clinical trials or large-scale outcome studies.

REFERENCES

1. Schwarzer AC, Aprill CN, Bogduk N. The sacroiliac joint in chronic low back pain. *Spine* 1995;20:31–37.
2. Derby R, Chen Y, Lee SH, Seo KS, Kim BJ. Non-surgical interventional treatment of cervical and thoracic radiculopathies. *Pain Physician* 2004;7:389–394.
3. Wilbourn AJ, Aminoff MJ. AAEM minimonograph 32: the electrodiagnostic examination in patients with radiculopathies: American Association of Electrodiagnostic Medicine. *Muscle Nerve* 1998;21:1612–1631.
4. Boden SD, McCowin PR, Davis DO, Dina TS, Mark AS, Wiesel S. Abnormal magnetic-resonance scans of the cervical spine in asymptomatic subjects: a prospective investigation. *J Bone Joint Surg Am* 1990;72:1178–1184.
5. Teresi LM, Lufkin RB, Reicher MA, et al. Asymptomatic degenerative disk disease and spondylosis of the cervical spine: MR imaging. *Radiology* 1987;164:83–88.
6. Date ES, Kim BJ, Yoon JS, Park BK. Cervical paraspinal spontaneous activity in asymptomatic subjects. *Muscle Nerve* 2006;34:361–364.
7. Gilad R, Dabby R, Boaz M, Sadeh M. Cervical paraspinal electromyography: normal values in 100 control subjects. *J Clin Neurophysiol* 2006;23:573–576.
8. Cho Charles S, Ferrante MA, Levin KH, Harmon RL, So YT. Utility of electrodiagnostic testing in evaluating patients with lumbosacral radiculopathy: an evidence-based review. *Muscle Nerve* 2010;42:276–282.
9. Chichkova RI, Katzin L. EMG and nerve conduction studies in clinical practice. *Practical Neuro* 2010;9:32–38.
10. Spengler DM, Ouellette EA, Battié M, Zeh J. Elective discectomy for herniation of a lumbar disc: additional experience with an objective method. *J Bone Joint Surg Am* 1990;72:230–237.
11. Annaswamy TM, Biener SM, Choutea W, Elliott AC. Needle electromyography predicts outcome after lumbar epidural steroid injection. *Muscle Nerve* 2012;45:346–355.
12. Dillingham TR. Electrodiagnostic approach to patients with suspected radiculopathy. *Phys Med Rehabil Clin N Am* 2002;13:567–588.
13. Haig AJ. Clinical experience with paraspinal mapping: I: neurophysiology of the paraspinal muscles in various spinal disorders. *Arch Phys Med Rehabil* 1997;78:1177–1184.
14. Nardin RA, Raynor EM, Rutkove SB. Fibrillations in lumbosacral paraspinal muscles of normal subjects. *Muscle Nerve* 1998;21:1347–1349.
15. Boden SD, Davis DO, Dina TS, Patronas NJ, Wiesel SW. Abnormal magnetic-resonance scans of the lumbar spine in asymptomatic subjects: a prospective investigation. *J Bone Joint Surg Am* 1990;72:403–408.
16. Malanga GA, Nadler SF. Nonoperative treatment of low back pain. *Mayo Clin Proc* 1999;74:1135–1148.
17. Cinotti G, Postacchini F, Weinstein JN. Lumbar spinal stenosis and diabetes: outcome of surgical decompression. *J Bone Joint Surg Br* 1994;76:215–219.

18. Chiodo A, Haig AJ, Yamakawa KJ, Quint D, Tong H, Choksi VR. Magnetic resonance imaging vs. electrodiagnostic root compromise in lumbar spinal stenosis: a masked controlled study. *Am J Phys Med Rehabil* 2008;87:789–797.
19. Haig AJ, Geisser ME, Tong HC, et al. Electromyographic and magnetic resonance imaging to predict lumbar stenosis, low-back pain, and no back symptoms. *J Bone Joint Surg Am* 2007;89:358–366.
20. Atlas SJ, Nardin RA. Evaluation and treatment of low back pain: an evidence-based approach to clinical care. *Muscle Nerve* 2003;27:265–284.

STUDY FUNDING

No targeted funding reported.

DISCLOSURES

The authors report no disclosures relevant to the manuscript. Go to Neurology.org/cp for full disclosures.

Related articles from other AAN physician and patient resources

Neurology® ● www.neurology.org

Assessment: Use of epidural steroid injections to treat radicular lumbosacral pain: Report of the Therapeutics and Technology Assessment Subcommittee of the American Academy of Neurology

March 6, 2007;68:723-729.

Continuum: Lifelong Learning in Neurology® ● www.aan.com/continuum

Spinal Cord, Root, and Plexus Disorders

August 2011.

Neurology Today® ● www.neurotodayonline.com

What to do for neck pain: Spinal manipulation, medication, or home-based exercise? New study weighs in

April 19, 2012;12:33-34.

After epidural stimulation, spinal cord injury patient stands and treadmill steps

June 16, 2011;11:1,11.