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Electrodiagnosis of Radiculopathy

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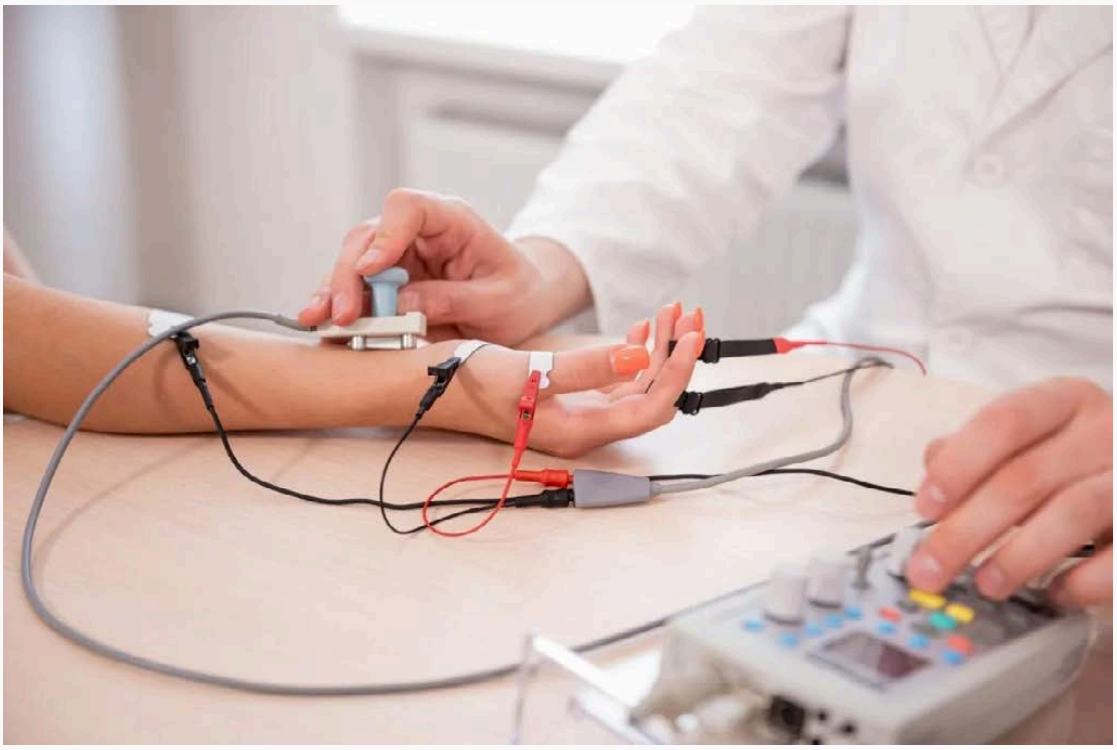
ABSTRACT

Electrodiagnostic Studies for cervical and lumbar radiculopathy are potential objective confirmation of true radiculopathy for impairment rating purposes. Many physicians are unaware of the neurophysiologic basis and the caveats for interpreting this testing. Electrodiagnostic testing can confirm a neurological lesion for neuropathic pain, but there is no electrodiagnostic test for nociceptive pain or nociplastic pain.

Historically the AMA *Guides* have granted larger impairments to those with verifiable radiculopathy, as opposed to those with symptoms that might be radicular (non-verifiable radicular complaints). Editions 1, 2, & 3 required the sensory or motor neurologic physical exam to be abnormal to document the neurologic injury of radiculopathy. Beginning with the 4th Edition (1993) the *Guides* recognized that electrodiagnostic testing can verify objective nerve root injury, and Editions 4, 5, & 6 published electrodiagnostic criteria for the diagnosis of radiculopathy.

When nerve axons are damaged, and neurotrophic chemicals are not able to flow from the cell nucleus (dorsal root ganglion for sensory axons – anterior horn cell of the spinal cord for motor neurons) where they are synthesized to the axon termination, axon death occurs.



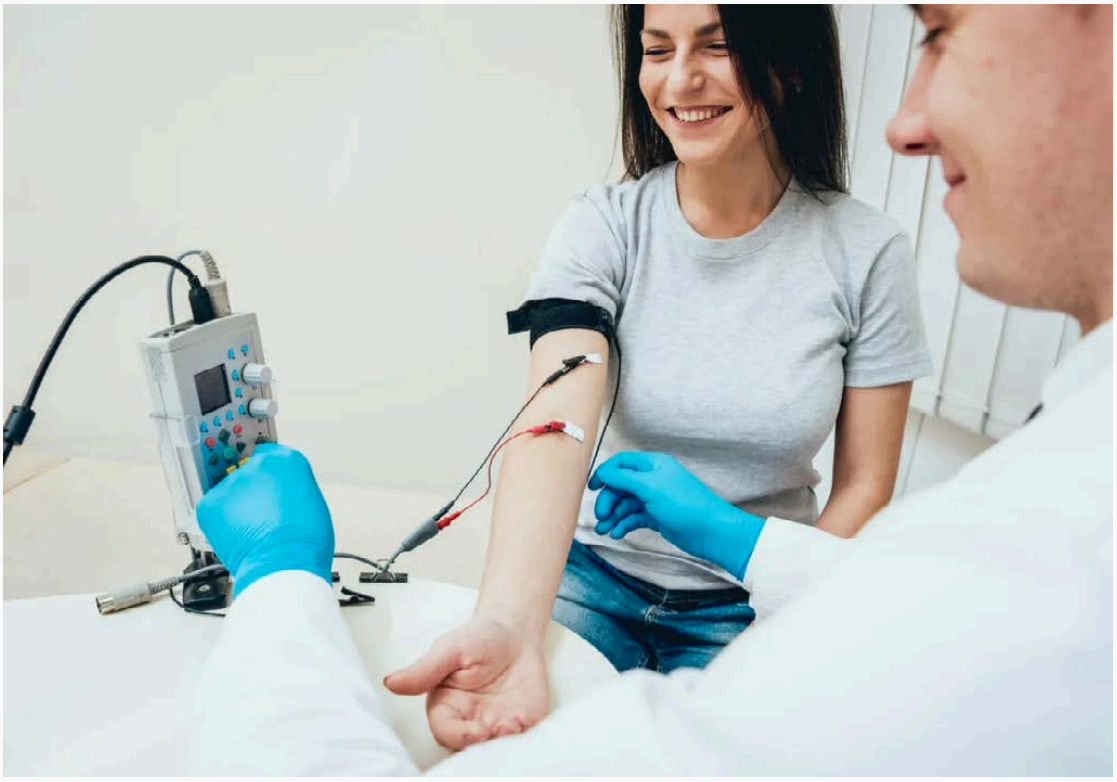
Traditional teaching is that acute denervation from axon death makes muscle cells “irritable”, and the muscle fibers depolarize spontaneously but abnormally. This results in needle EMG recording fibrillation potentials, positive waves, and perhaps (although much less commonly) complex repetitive discharges or fasciculations. These occur with any cause of peripheral nerve axon injury (e.g. transection, neuropathy) or with spinal nerve root injury (e.g. radiculopathy from disc herniation or spinal stenosis). With spinal nerve root injury, the fibrillations and positive waves occur in the paraspinal muscles first 7-8 days from onset (Johnson 1997) or 10-14 days after onset (Preston 2005). Fibrillations and positive waves occur in proximal limb muscles in 13-14 days or 14-21 days, and ultimately in the distal limb muscles by 14-21 days or 21-28 days (authorities differ slightly on time course, but more distal muscles are involved later in time, as the axons are longer).

Reinnervation of denervated muscle fibers by surviving axons of the same nerve root, or by axons from other non-compressed adjacent nerve roots occurs, as most skeletal muscles are innervated by axons from at least 2 nerve roots. As reinnervation occurs the motor unit potentials on needle EMG become polyphasic (cross the base line multiple times) and later with further reinnervation become high amplitude, long duration, polyphasic motor unit potentials. The first reinnervation change may occur at 4-6 weeks after onset (Johnson 1977), and the “chronic” motor units with high amplitude (>4 mV), long duration (> 12-14 msec), and polyphasia (> 4 baseline crossings) (Rodriguez-Carreno 2012) are known to persist for years. If only these chronic changes are present, electrodiagnostic testing cannot guess the age of the causative lesion.

Readers of *Guides* who must read and evaluate electrodiagnostic testing reports for impairment rating are encouraged to read the excellent 2 part American Association of Neuromuscular and Electrodiagnostic Medicine (AANEM) monographs on electrodiagnosis

of radiculopathy (Dillingham 2020) that unfortunately are not open access.

There is an extensive differential diagnosis for patients presenting with what seems like cervical (Grimm 2014, Kouri 2018, Sakthivelnathan 2023) or lumbar radiculopathy (Grimm 2015).



There are a number of caveats to remember when using electrodiagnostic testing reports for impairment rating.

CAVEAT #1

Needle electromyography (EMG) is a minimally invasive test and interpretation of the images and waveforms is challenging for those without extensive formal training in this testing. Ideally this testing is performed by physicians trained in electrodiagnosis during a neurology or a physical medicine and rehabilitation residency. If the electrodiagnostic findings don't fit with the clinical picture, the impairment rating physician may choose to disqualify the testing report, particularly if the credentials of the person performing the testing suggests suboptimal training. If the electrodiagnostic findings don't fit with the clinical picture, repeating the testing by a physician who has passed the AANEM qualifying exam may be helpful.

CAVEAT #2

The physician performing the testing should be the one interpreting the tests. A physical exam should precede the testing so that all muscles weak on physical exam are identified and thus considered for needle EMG testing. Testing may begin with a screening exam, but as the testing results become available, the physician is expected to recognize the need to add to a standard screening exam. This may include additional muscle EMG and/or additional nerve conduction tests (NCT), based on abnormalities identified.

CAVEAT #3

There are 5 potential outcomes of electrodiagnostic testing for radiculopathy.

1. Testing is normal. Testing may have been too soon after onset for changes to be present.
2. Testing may have been done with sufficient time between the onset, or major worsening, and yet the testing is normal. A purely sensory radiculopathy may still be present. However, the sensory physical exam is the neurologic physical exam testing most prone to bias if the physician is aware of the results of a spinal MRI, making evaluation of isolated sensory physical exam changes challenging (Suri, 2010).
3. Testing may be consistent with an acute single nerve root radiculopathy. (see #4 below)
4. Testing may not be consistent with radiculopathy, but consistent with another neurologic condition(s) (e.g. carpal tunnel syndrome, diabetic peripheral neuropathy, or mononeuritis multiplex). This includes testing not consistent with radiculopathy that identifies any abnormal finding(s).
5. Testing may be consistent with both radiculopathy AND ANOTHER neurologic condition, which is very challenging to interpret. A neurologist's consultation may be helpful.

CAVEAT #4

The current definition of radiculopathy by electrodiagnostic testing (Dillinghan 2020) is:

1. Acute: fibrillations and/or positive waves (or complex repetitive discharges) in two or muscles innervated by the *same* nerve root, but innervated by *different* peripheral nerves, with muscles

innervated by adjacent nerve roots showing no changes (normal), and with fibrillations and positive waves *also* in the appropriate paraspinal muscles (same spinal region, same side). A sensory nerve conduction study for a sensory nerve from the nerve root implicated by needle EMG should be performed (when possible) and should be normal, as the cell nucleus for sensory neurons is in the dorsal root ganglion which is normally in the neuroforamen and distal to the disc **protrusion**. Note that occasionally the dorsal root ganglion is compressed by a foraminal or far lateral disc or is anomalously positioned in the spinal canal, so the sensory study may be abnormal (Mondelli 2013 - 7% prevalence in confirmed radiculopathy). If abnormal, additional testing should be done to exclude plexus and peripheral nerve injury or disease.

2. **Chronic**: absence of fibrillations and positive waves but presence of high amplitude, long duration, polyphasic motor units on minimal voluntary contraction in the same distribution of limb muscles mentioned above. Since motor units are not traditionally evaluated in paraspinal muscles (which requires minimal voluntary contraction of the tested muscle), chronic radiculopathy does not require the presence of chronic axon injury motor units in the paraspinal muscles. If the only abnormality is the presence of chronic motor unit changes, the age of the neuropathy cannot be established by electrodiagnostic testing. The best specificity (97% - few false positives) is with requiring >30% of the motor units visualized to be polyphasic (Dillingham 2020).
3. **Mixed**: both the fibrillations and positive waves of acute radiculopathy and the high amplitude long duration polyphasic motor units of chronic radiculopathy are present, representing “acute on chronic” disease or injury.

CAVEAT #5

Paraspinal muscle needle EMG cannot be evaluated in patients who have had prior posterior approach spinal surgery in the same region (muscle splitting or muscle retraction during surgery injures the paraspinals' innervation). Radiofrequency ablation may also have created injury to motor axons to the paraspinals. Dillingham cites studies showing motor axons to the paraspinal muscles may document fibrillations or positive waves that extend up to 2 levels above the involved nerve root, and anatomic dissections document innervation extending to 2 spinal levels below a nerve root (Saito 2013). Thus, localizing the level of nerve root injury producing denervation (fibrillations and positive waves) in paraspinal muscles is not precise and should *not* be attempted. There is literature controversy as to whether, or not the most medial lumbar paraspinal (Kottlors 2008, Wu 2008), the multifidus is innervated by only one, or by multiple nerve roots. The neuropathy of aging commonly produces fibrillations and positive waves in the paraspinals (Haig 2002) that increase in frequency with age. In patients over 50 this may be the explanation for paraspinal muscle abnormalities. Thus, if the only abnormality suggesting radiculopathy is in the paraspinal muscles, this is *not* objective evidence of radiculopathy for impairment rating purposes.

CAVEAT #6

The AMA *Guides* has had, in multiple editions, tables showing for several cervical and lumbar nerve roots the common location of symptoms, sensory deficit, muscles with motor weakness, and reflex changes with radiculopathy involving that nerve root. However, other sources (Preston 2005, Dillingham 2020) have similar tables, and the tables are not identical as to the symptom locations and deficits from single nerve root radiculopathy. Further complicating the interpretation, anatomic anomalies are common. Text-book pictures

of the brachial plexus or lumbosacral plexus differ, and “pre-fixed” or “post-fixed” plexuses are well known. The “textbook” structure of the brachial plexus is documented in 37%-77% of anatomic cadaver dissections (McAnany 2019). Prefixation of the plexus occurs when the C4 nerve root provides considerable contribution to the plexus with the T1 nerve root provides minimal to no contribution. A postfixed plexus occurs when the plexus receives little to no contribution from the C5 nerve root and instead receives considerable innervation from the T2 nerve root. A prefixed plexus occurs more frequently (McAnany 2019). This means the EMG diagnosis of potential radiculopathy may be correct, but the designation of the involved nerve root may be incorrect by a spinal level, or more rarely 2 levels, but not as to the side of the radiculopathy. Typically, neither symptom location, nor physical exam of deficits, nor needle EMG can distinguish C6 nerve root from C7 nerve root syndromes (McAnany 2019). Thus, the physical exam and electrodiagnostic testing can confirm the presence of a deficit, but the anatomic cause of the deficit, and thus the potential “surgical target” should be based on imaging.

CAVEAT #7

It is well established that a 6 muscle EMG and a few nerve conduction studies are adequate to determine “normal” – high specificity for no radiculopathy (Dillingham 2020). The recommended needle EMG screen for potential cervical radiculopathy is to test the deltoid, triceps, pronator teres, abductor pollicis brevis, extensor digitorum communis and the paraspinal muscles, although other muscle combinations are options with nearly the same accuracy. The recommended needle EMG screen for potential lumbar radiculopathy is to test the anterior tibial, posterior tibial, medial gastrocnemius, vastus medialis, tensor fascia lata, and the paraspinal muscles, although other muscle combinations are options (Dillingham 2020). Sensory nerves to test for SNAP amplitude are the radial or the median sensory nerve to the thumb for the C6 root, the median nerve

to the middle finger for the C7 root, the ulnar nerve to the little finger for the C8 root, and the medial antebrachial cutaneous nerve for the T1 nerve root; the saphenous nerve for the L4 root, the superficial peroneal nerve for the L5 root, and the sural nerve for the S1 nerve root. Other nerve roots do not have a cutaneous sensory nerve that can be easily tested, just as the C3, C4, L1, L2, L3, and S2-4 nerve roots do not have a motor nerve innervated muscle that is easy to test by nerve conduction and that therefore can help to identify involved nerve root (Sarwan 2023, Tamarkin 2022, Hashimoto 2023).

CAVEAT #8

L2-L4 radiculopathies are typically grouped. It is challenging to distinguish an isolated spinal lesion due to the broad L2-L4 myotomal overlap of the anterior thigh muscles, as well as adjacent root overlap (Tamarkin 2022, Sakthivelnathan 2023).

CAVEAT #9

Older studies when MRI was not as precise documented 50% of patients referred for electrodiagnostic testing for cervical radiculopathy with normal physical exams had radiculopathy diagnosed by EMG (Dillingham 2020). Whether this is repeatable today with better imaging results and when fewer EMGs are ordered (with the surgeons frequently ordering EMGs hoping for a “normal” study in patient for whom they are hesitant to offer surgical treatment), is not known.

CAVEAT #10

Decreased recruitment of motor units on voluntary muscle contraction may be noted but is not a criterion for radiculopathy. Decreased recruitment is also seen with proximal upper motor

neuron injury of disease (stroke, traumatic brain injury, spinal cord injury, and also with poor voluntary effort).

*Jump to **references** for this article.*

An Open Letter to Physicians Treating Tennessee Workers' Compensation Patients

Consider the Lessons of Residency to Treat Workers' Compensation Patients and Avoid UR Denials

Dr. J. Wills Oglesby, Dr. James Talmage, Dr. Robert Snyder

Left to Right: Dr. J. Wills Oglesby, Dr. James Talmage, Dr. Robert Snyder

AN OPEN LETTER TO PHYSICIANS TREATING TENNESSEE WORKERS' COMPENSATION PATIENTS:

Do you remember the fear during your residency that was associated with presenting patients to the faculty, your peers and the medical students during "pre-op indications conference"? The history, physical findings, review of the pertinent literature, treatment alternatives, indications, contraindications, risks, and potential for the patient's recovery all had to be presented in a coherent stepwise fashion. A simple survey or a snapshot summary would be inadequate and invite ridicule or perhaps an inquisition. Careful correlation of the patient's symptoms, physical findings and pertinent imaging studies were incorporated in this discussion. Consideration of alternative diagnoses and appropriate nonoperative management was necessary. Other potential pain generators had to be discussed and excluded, i.e. an appropriate differential diagnosis list had to be generated and disproved. Finally, a frank assessment of the risks and benefits had to be considered so that appropriate informed consent could be obtained. Then, and only then, after answering the faculty's questions, could you proceed to surgery with a comprehensive plan and multiple alternative subsequent steps, depending on the findings at surgery.

We all recognize the pressure that time and business place on the practice of medicine today. However, we must not compromise the goals of (1) making an accurate and explainable diagnosis, (2) providing appropriate care, and (3) doing our best to help the patients recover. Skipping steps, neglecting to consider alternative diagnoses, failing to carry out and document thorough examinations and nonoperative care will lead to errors and compromise patient outcomes. Taking shortcuts may also lead you to assume that your surgery helped the patient, when the passage of time and natural healing might have accomplished the same thing. Remembering how you had to defend your evaluations, plans and actions at

“preoperative indications conference” will serve you and your patients well.

The Official Disability Guidelines, or ODG, were developed by the Work Loss Data Institute in 1995 and may function in much the same way as the principles of “pre-op indications conference.” ODG uses evidence-based medicine to guide evaluation and treatment of patients. It is not a train track without switches, turns, or sidings, but is a valuable guide to current knowledge of appropriate diagnostic and therapeutic measures. Updates are provided on a regular basis, including advances in technology and evidence/literature. It is worthwhile to read, consider, and incorporate these documents into your practice[1]. They can help with the thoroughness of your preoperative evaluation, can remind you not to skip important steps in the diagnostic and treatment pathways, and help you anticipate objections when you think it is in your patient's best interest to have an exception to the guidelines. This is true whether you are dealing with commercial, workers’ compensation, or other sources of the necessary authorizations. A free webinar is on the State of Tennessee website under the Department of Labor and Workforce Development about the use of the ODG: ODG by MCG Training for the State of Tennessee

The Tennessee Bureau of Workers’ Compensation Medical Directors rarely see medical records from the requesting surgeon submitted to the adjuster for payment pre-authorization that cite the ODG criteria for the requested procedure and detail how the patient meets those criteria -- or that the patient should be considered an exception to those criteria. The Medical Directors always see the Utilization Review Physician cite criteria and analyze cases based on the ODG criteria in care denials. Investing in an ODG subscription and having a computer stored “copy and paste” of the criteria for each surgeon’s ten most frequent surgical procedures would likely dramatically decrease utilization review denials.

At the Bureau of Workers Compensation, our goal is to help patients obtain the best care and outcomes possible by encouraging the best physicians to care for injured workers, training physicians in the system, and determining appropriate treatment alternatives when a utilization review denial is appealed. When treatment requests that have been denied by the carrier are appealed to the Bureau, we look for:

1. A well-established diagnosis which correlates with the history, the symptoms, the physical examinations and imaging studies;
2. A thoughtful treatment plan, developed with patient input as appropriate, which is based on the evolution of symptoms and findings;
3. Appropriate nonoperative management trials that are well documented prior to advancing to surgery or other invasive procedures.

These considerations should apply to all your patients. Keeping them in mind will assist you as you strive to deliver the most beneficial and efficient care. Remember the “unicorn’s approach-in my hands” may lead to an overly optimistic interpretation of interventional and surgical outcomes. Be aware of the placebo effect. Placebo studies are rarely done in surgery, unlike with medications, but are remarkable as a humbling reminder to the surgeon that many patients improve at about the same rate with sham surgery. Study, remember, and apply the evidence-based data regarding some of our most frequent and popular procedures. Arthroscopic partial meniscectomy[2–7], and arthroscopic acromioplasty[8–10] are done with great frequency, but the evidence of long-term, well-documented studies does not support these procedures at the rate that many surgeons believe. The role of observer bias and selective memory on the part of surgeons can compromise decision-making and outcomes. (The article by the three BWC Medical Directors regarding knee surgery in the summer edition of this Review is worth reviewing.)

Surgeons have remarkable power and influence, but also responsibility. Surgeons are under constant pressure to perform perfectly and solve the presenting problem for their patients. Surgeons must, to optimize outcomes for their patients and minimize stress for themselves, practice good medicine. As one of my professors said, “If you always do the right thing, it will turn out okay.” This does not mean that all patients will have good outcomes, but it does mean that you will have done the best you can every day.

Remember your vital lessons from residency, and make use of all the available current tools and information:

1. Listen to your patient. The history gives you the diagnosis most of the time, if you pay attention and ask the right questions.
2. Perform thorough, accurate and reproducible physical examinations frequently, especially if treatment recommendations are unsuccessful or new symptoms are presented. The new AMA Guides to the Evaluation of Permanent Impairment update will remind you of the proper techniques for physical examination if they have become vague over the years.
3. Make a list and document a differential diagnosis on each patient, i.e., exclude other potential pain generators. Document the reasoning for excluding some before jumping into aggressive treatment.
4. Order appropriate studies, being mindful of their costs and benefit.
5. Allow time for natural healing and the evolution of symptoms for your patient.
6. When surgery is necessary, perform the correct procedure with technical expertise.
7. Manage the patient post-operatively to assure the best outcome. They put themselves in your hands and expect you to be there

during their convalescence. Be sure they get the help and attention they deserve after surgery.

The pressure on physicians to treat more patients, generate more dollars for the practice, and make no mistakes is immense. Relief is not in sight. Your first obligation is to your patient. Remember to always do the right thing, and it will be okay--maybe not perfect, but the best you can do.

Remember and apply the lessons and principles you were taught in "pre-op indications conference." They will serve you and your patients well, improving the effectiveness of your decision-making, the efficiency of your practice by increasing the accuracy of your diagnosis and treatment, and by reducing denied treatment requests and the need for appealing those denials.

Jump to **references** for this article.

Understanding the “Course of Employment” Requirement

Understanding the “Course of Employment” Requirement

By Jane Salem, staff attorney, Nashville

Jane Salem

> Physician: "So what brings you here?"
>
> Patient: "Well, doc, the craziest thing happened at work…"

If you treat workers' compensation patients for any length of time, you're bound to have that conversation at some point. They didn't lift a heavy object and hear a "pop." They didn't slip and fall. No, something really unusual went down at work. When that happens, the question becomes, is the incident related to work? Is the claim compensable?

In Tennessee, the starting point is section 50-6-102(12), which requires that an injury arise primarily out of and in the course and scope of employment.

In *Blankenship v. American Ordnance Systems*, the Supreme Court explained that this is a two-pronged question. "Course of employment" and "arising out of" are not synonymous. Rather:

> "An injury occurs in the course of employment if it takes place while the employee was performing a duty he or she was employed to perform. That is, an injury occurs in the course of employment when it takes place within the period of the employment, at a place where the employee reasonably may be, and while the employee is fulfilling work duties or engaged in doing something incidental thereto. Thus, the course of employment requirement focuses on the time, place, and circumstances of the injury."

The high court continued:

> "In contrast, arising out of employment refers to causation. An injury arises out of employment when there is a causal connection between the conditions under which the work is required to be performed and the resulting injury. The mere presence of the employee at the place of injury because of the employment is not enough, as the injury must result from a danger or hazard peculiar to the work or be caused by a risk inherent in the nature of the work."

What's important for physicians to know at this juncture is, your job is often to decide the second prong, causation, only. Although clearly, how the accident happened, the course of employment, can influence this outcome.

Three fairly recent appellate decisions exemplify just how … unusual … some fact patterns can be.

For example, did you hear about the employee who had clocked out from his job in the kitchen of a restaurant, and 40 minutes later, at a designated smoking area behind the restaurant while waiting for a ride home, a possum ran out from behind a dumpster and startled him? He fell, hurting his shoulder and back. Is this compensable?

Yes. The Appeals Board reasoned, "Given Employer's acquiescence in allowing employees to stay on premises in the designated break area and wait for rides or mingle with co-workers without any stated limit, we conclude the evidence does not preponderate against the trial court's conclusion that this was a reasonable amount of time to remain on the premises and, therefore, Employee's injury occurred in the course and scope of the employment." The case, decided this past March, is *Pridgen v. Texas RoadHouse Holdings, LLC*.

Or have you heard about the employee, a "field salesman" who experienced "gastrointestinal distress" at the office that resulted in

the need for him to go home, shower, and change before making his sales calls? On his way home, in the company car, he was in an accident. Compensable?

Yep. Where an employer furnishes transportation as an incident of the employment, an injury suffered by the employee while going to or returning from his work in the vehicle furnished arises out of and is within the course of the employment. The Board rejected the contention that the employee here was on a “personal errand” at the time of the accident. Rather, the employee was using his company vehicle to return home to change before making sales calls for the employer. Although the employee admitted his errand was personal in nature, the errand also had a business purpose and contributed to the "furtherance of his work." The case is *McCorkhill v. Landon Electric Co., Inc.*, issued in 2023.

Finally, what about the employee, a house painter working outside when the weather became “really, really windy,” causing him to take cover inside a nearby porta-potty. When he left it, he was injured by a limb from a dead tree that had fallen. Compensable?

Nope. The Supreme Court Workers’ Compensation Panel held the storm was an “act of God,” outside the employer’s control. The employee used a porta potty that happened to be near his worksite; the employer hadn’t placed it there or instructed its employees to use it. The panel rejected the employee’s argument that his injury resulted from an unidentified property owner’s failure to cut down a dead tree and therefore wasn’t an act of God. But the employee hadn’t observed anything overtly dangerous about the location of the porta potty, and his work as a painter placed him at no increased risk peculiar to his employment that a dead tree might fall on him. Instead, the general public at the same time and in the same place bore the same risk. The case is *Rosasco v. West Knoxville Painters, LLC*, issued in 2021.

In sum, in the workers' compensation realm, sometimes employees suffer injuries in ways that might seem unimaginable and/or bizarre. Sometimes accidents at work relate to work, and sometimes they don't. The "course of employment" aspect is highly fact-intensive. And although the cases described above are all recent, they all rely on legal principles that were developed over the past 105 years that workers' compensation has existed in Tennessee.

In fact, just one year after the law took effect, the Tennessee Supreme Court first discussed the "course of employment" in *Hinton Laundry Co. v. De Lozier*. The justices reversed an order granting benefits to a laundress who became injured while ironing a skirt for a coworker. All of the employees received a fringe benefit of being allowed to do their own laundry on Mondays. But because this worker did so on a Friday and after her regular work hours, "[h]er act of pressing the skirt … was purely a voluntary one, and was being done by the petitioner as a matter of accommodation to her fellow employee. The evidence is uncontradicted that the defendant had no interest … in the service which was being performed by petitioner at the time of her injury."

So when an injured worker relates an odd tale of how they became injured, keep an open mind. If you didn't already know this, now you do: sometimes weird stuff happens at work. Record the history as completely and accurately as possible, including the "time, place and circumstances of the injury." Then consider if what they're saying could cause what you're seeing.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AdMIRable Review accepts electronic submission for articles related to Tennessee Workers' Compensation. Manuscripts prepared in accordance with the American Psychological Association (APA) guidelines are preferred. Submission of a manuscript implies permission and commitment to publish in AdMIRable Review. Submission and inquires should be directed to AdMIRable Review, Editorial Staff, at Jay.Blaisdell@tn.gov.

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