

Low Back Pain

Evidence-based Diagnosis and Treatment

Mike Roscoe, PhD, MPAS, PA-C, Alyssa Nishihira BS, BSHS, PA-S

Low back pain (LBP) is one of the most common reasons for an office visit, but most cases—at least 95%—have a benign underlying cause. Evaluation of LBP patients in the primary care setting, therefore, must focus on identifying “red flags” in the history and physical exam that suggest a significant underlying process requiring further work-up, including imaging. This evidence-based approach helps control costs and prevents the detrimental effects of unnecessary testing.

CE/CME INFORMATION

Earn credit by reading this article and successfully completing the posttest at www.clinicianreviews.com/cecme/cecme.html. Successful completion is defined as a cumulative score of at least 70% correct.

This program has been reviewed and is approved for a maximum of 1.0 hour of American Academy of Physician Assistants (AAPA) Category 1 CME credit by the Physician Assistant Review Panel. [NPs: Both ANCC and the AANP Certification Program recognize AAPA as an approved provider of Category 1 credit.] Approval is valid for one year from the issue date of **May 2016**.

LEARNING OBJECTIVES

- Identify “red flag” items in the history and physical exam that make low back pain (LBP) “complicated.”
- Stratify patients into three categories: simple back pain, complicated back pain, and back pain with sciatica.
- Discuss when appropriate additional testing/imaging is needed based on LBP categories.
- Discuss patient perceptions and costs associated with imaging and LBP.
- Describe basic treatment options for noncomplicated acute LBP.

Low back pain (LBP) plagues many Americans and is a common reason for office visits in the United States. In 2010, back symptoms were the principal reason for 1.3% of office visits in the US.¹ Recent data suggest that 75% to 85% of all Americans will experience an episode of LBP at least once in their lifetime.² It is the leading cause of years lived with disability in the US³ and is a common reason for work disability. From a health care system standpoint, LBP imposes a considerable burden, accounting for more than \$85 billion annually in direct costs.²

The etiology of LBP can be related to several anatomic and physiologic changes. Potential origins of LBP include, but are not limited to, pathology of the vertebrospinal ligaments, musculature, facet joints, fascia, vertebra and vertebral disks, and the extensive neurovascular components of the lumbar region. Although the potential causes of LBP are many, the majority of patients presenting with acute LBP usually improve with minimal clinical intervention within the first month. This is true even for patients who report limitations in daily activities and those with severe, acute cases of LBP.

A single standard of care for patients presenting with LBP has not been established. The wide array of choices for diagnosis and treatment of LBP is one factor that hinders the development of a standard diagnostic protocol. The challenge to clinicians when diagnosing LBP is to differentiate the patients with benign, self-limiting LBP (simple), who comprise the vast majority of LBP patients, from the 1% to 5% with a serious underlying pathology (complicated).⁴

Mike Roscoe is the PA Program Director at the University of Evansville, Indiana. **Alyssa Nishihira** is in her final year of the PA Program at Butler University, Indianapolis; after graduation, she will be practicing at Advanced Neurosurgery in Reno, Nevada. *The authors have no financial relationships to disclose.*

STRATIFICATION OF LOW BACK PAIN

Koes and colleagues analyzed 13 different national guidelines and two international guidelines for the management of LBP.⁵ They found that the guidelines consistently recommend focusing the history and physical exam (HPE) on identifying features suggestive of underlying serious pathology, or “red flags,” and excluding specific diseases.⁵ They also found that none of the guidelines recommends the routine use of imaging in patients without suspected serious pathology.⁵ The American College of Radiology simplified this approach to patients with LBP by creating a list of red flags to look for during the HPE.³

The presence of red flags indicates a case of complicated LBP, and patients who present with them should undergo additional diagnostic studies to screen for serious underlying conditions (see the Table, page 40).

The HPE should ultimately separate patients into three categories to determine the need for imaging (and course of treatment): (1) simple acute back pain, (2) complicated back pain with red flag (ie, a potential underlying systemic disease), and (3) LBP with neurologic deficits potentially requiring surgery.⁵

Simple acute low back pain

Up to 85% of patients presenting with LBP may never receive a definitive diagnosis due to lack of specific symptoms and ambiguous imaging results.⁶ Clinicians can assume that LBP in these patients is due to a mechanical cause, by far the most common cause of LBP.⁷ It is therefore more useful to rule out serious or potentially fatal causes of LBP (complicated LBP) rather than rule in a cause for patients presenting with LBP.

It is generally accepted among practitioners that a thorough HPE alone is sufficient for evaluating most patients presenting with acute LBP lasting less than four weeks.⁵ Patients presenting without red flags should be assured that improvement of acute LBP is



typical, and that no diagnostic intervention is needed unless they do not improve as expected per patient or provider (eg, in terms of activities of daily living or work restrictions). The Figure (see page 41) depicts an appropriate approach to diagnosis and treatment in patients presenting with LBP.⁸ Clinicians should also offer patient education for self-care and discuss noninvasive treatment options, including pharmacologic and nonpharmacologic therapy.⁹

Low back pain with red flags (complicated)

Patient history is more useful than the physical exam in screening for spinal malignancies. In one particular combination (age > 50, history of cancer, unexplained weight loss, and failure to improve with conservative therapy), red flag symptoms are 100% sensitive for detecting malignancy.¹⁰ However, malignant neoplasms of the spine make up less than 1% of the diagnoses of patients presenting with LBP in primary care.⁴ Additionally, Deyo and Diehl reviewed five studies of a large series of consecutive spine films with large sample sizes and found the incidence of tumors, infections, and inflammatory spondyloarthropathies together were present in less than 2%.¹¹ This low prevalence underscores the challenge of diagnosing serious pathology of the spine in the primary care setting.

continued on next page >>

>> *continued from previous page*

TABLE

Red Flags for a Potentially Serious Underlying Cause of Low Back Pain

Age > 50
Duration > 4 wk
Focal neurologic deficit(s)
History of abdominal aortic aneurysm
History of cancer
Immunosuppression
IV drug use
Prolonged use of corticosteroids, osteoporosis
Trauma
Unexplained fever
Unexplained weight loss

Note: This is not a comprehensive list of red flags, but rather is a guide to common concerns in patients with low back pain or radiculopathy.

Source: Staiger et al. *Postgrad Med.* 1999.⁴⁰

Patients with complicated back pain presenting with red flags should always be examined for an underlying systemic disease. There is one red flag that, seen in isolation, meaningfully increases the likelihood of cancer: a previous history of cancer.⁴ Otherwise, inflammatory markers (eg, erythrocyte sedimentation rate) can be used to determine the need for advanced imaging (see the Figure).¹⁰

Low back pain with neurologic findings (sciatica)

Screening (HPE) for neurologic damage is difficult because traditional findings of neurologic injury (paresis or muscle weakness, impaired reflexes, sensory deficits, and decreased range of motion) all have low sensitivity with higher specificity.¹² For this reason, these tests are of limited value as *screening* tools during the HPE. Specific exams, such as the straight leg raise and crossed straight leg tests, are also of limited value, especially in the primary care setting, because of inconsistent sensitivity and specificity.

This is the primary reason that the HPE in patients with LBP who have neurologic findings must

include evaluation for urgent findings (see the Figure). If any red flags are present, advanced imaging is immediately warranted. Otherwise, inflammatory markers and plain radiography may be obtained, and advanced imaging may be considered if the plain radiography and/or inflammatory markers are abnormal.

There is also an approach that advocates the use of advanced imaging in patients with significant functional disability due to their LBP. Two questionnaires, the Oswestry Low Back Pain Disability Index and the Roland-Morris Disability Questionnaire, evaluate subjective data to determine a patient's functional disability due to LBP. The validity of both tests has been confirmed.¹³

DIAGNOSTIC IMAGING

The majority of patients presenting with LBP without concerning symptoms can be assumed to have non-specific mechanical back pain. These patients do not need radiography unless the pain has not improved after four to six weeks of conservative care, because plain radiographs often detect findings (degenerative joint disease, bone spurs, spondylosis) that are unrelated to symptoms.⁹ Advanced imaging is generally recommended only for LBP patients with red flags due to the potentially critical nature of these cases.⁵ Patients with LBP presenting with any of these factors require further testing, even if the duration of their pain is less than four weeks.

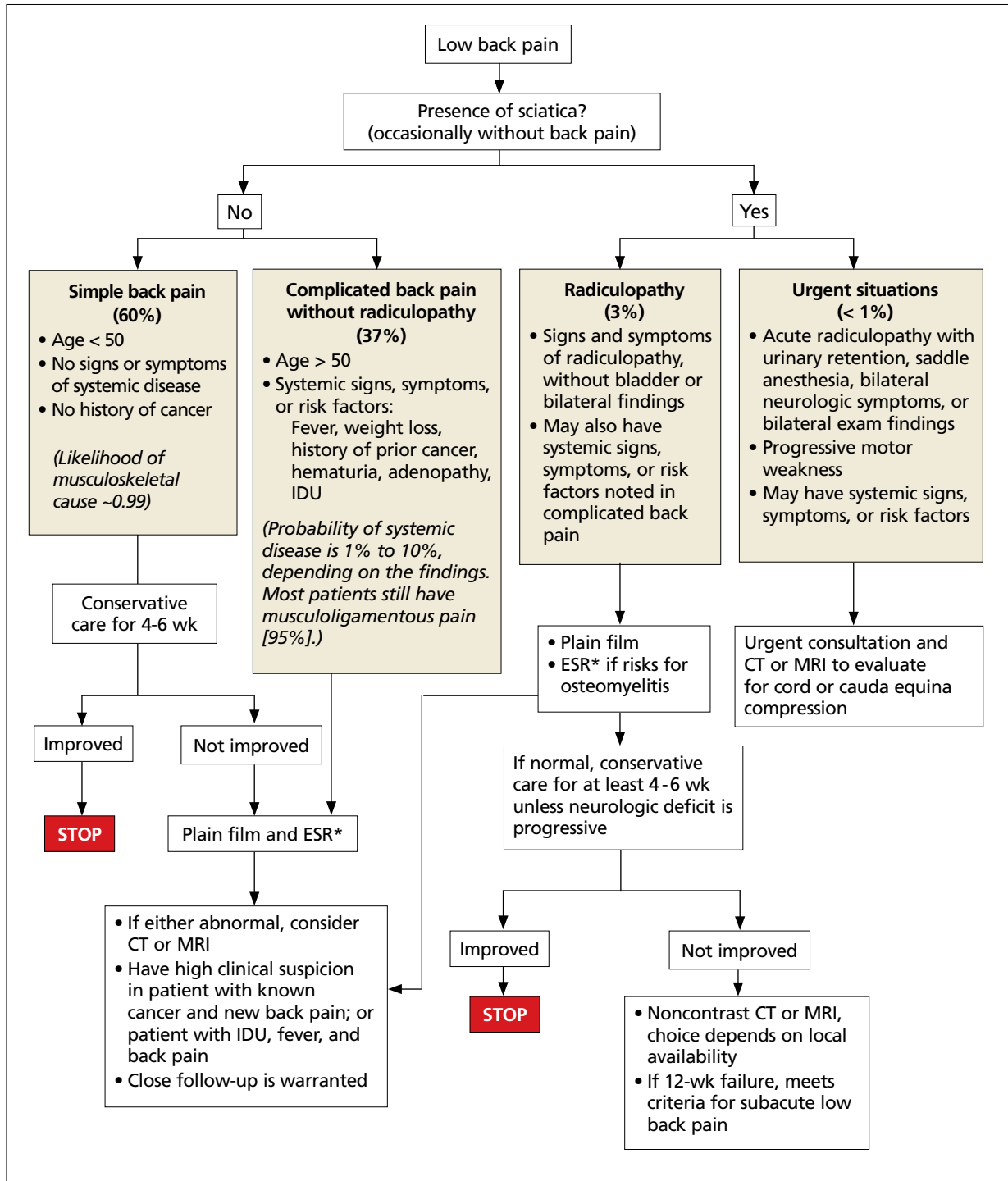
If a patient's LBP persists beyond four weeks, the clinician must decide which diagnostic test to order. General medical knowledge suggests that MRI is superior to plain radiography because it shows soft tissue and can detect more concerning abnormalities, such as infections, cancer, and metastatic tumors. CT is better for showing bony abnormalities, but these rarely correlate with a patient's LBP, and CT subjects patients to levels of radiation that can increase cancer risks.¹⁴ Plain radiography in this cohort (LBP > 4 wk) is not generally recommended as it cannot show intervertebral discs or evaluate the degree of spinal stenosis as accurately as MRI. Additionally, these lumbar radiographs expose patients to more than 35 times the radiation delivered in a single chest radiograph.¹⁵

COSTS AND PATIENT OUTCOMES

The estimated cost of unnecessary imaging for LBP is \$300 million per year.¹⁶ There is evidence of a strong association between advanced lumbar

FIGURE

Evaluating Patients with Low Back Pain



Abbreviations: CT, computed tomography; ESR, erythrocyte sedimentation rate; IDU, injection drug use; MRI, magnetic resonance imaging.

*Some clinicians measure C-reactive protein in addition to ESR as an inflammatory marker.

Reproduced with permission from Staiger TO, Gatewood M, Wipf JE, Deyo RA. Diagnostic testing for low back pain. In: Post TW (ed), UpToDate, Waltham, MA. Accessed March 16, 2016. Copyright © 2015 UpToDate, Inc. For more information visit www.uptodate.com.

spine imaging and increased rates of surgery and significantly higher total medical expenditures.^{17,18} One study examined patients with nonspecific LBP who either received MRI within 30 days post-onset (defined as “early MRI”) or did not receive MRI. Early-MRI patients had significantly higher total medical expenses (\$12,948, $P < .0001$) than the no-MRI group.¹⁷ The early-MRI group also had significantly longer periods of disability and were less likely to go off disability than the no-MRI group ($P < .0001$).

Cost-effectiveness studies of plain radiographs, dating back to 1982, have yielded similar findings. Liang et al suggested that if radiography was done routinely at the initial visit in patients with acute LBP but no red flags, the cost would be more than \$2,000 (in 1982 dollars) to avert one day of pain.¹⁹ A more recent study examined patients with acute LBP who received MRI, with one group blinded (both patients and physicians) to their MRI results for six months while the other group received their results within 48 hours.²⁰ All patients underwent a physical exam by a study coordinator, and treatment was assigned prior to imaging. At six weeks and one year, there was no significant difference in treatment assignments or self-reported surveys between groups, indicating that the MRI results had no significant influence on patient outcomes.

Despite the large increase in the use of advanced diagnostic imaging aimed at improving patient care and outcomes, there is a lack of data showing any correlative or causative connection between the two. Given this lack of evidence, and the potentially detrimental radiation exposure and increased costs to patients, clinicians should follow evidence-based guidelines when considering diagnostic imaging in patients presenting with LBP.

PATIENT PERCEPTION

Patient satisfaction plays a very important role in health care and may correlate with compliance and other outcomes. One study showed that while radiography in patients with LBP was not associated with improved clinical outcomes, it did increase patients' satisfaction with the care they received.²¹ A study that grouped patients requiring imaging for LBP into rapid MRI and plain film radiography cohorts found that patients who received rapid MRI were more assured by their results than were patients in the radiography group (74% vs 58%, $P = .002$).²² Both groups showed significant clinical improvement in the first

three months, but there was no difference between groups at either the three- or 12-month mark. In both groups, reassurance was positively correlated with patient satisfaction (Pearson correlation coefficients, 0.55-0.59, $P < .001$).

Patients may be reassured by imaging, even when it is unnecessary. Effectively explaining symptomatology during the HPE to patients with LBP should be of high priority to clinicians. A study found that when patients with mechanical LBP did not receive an adequate explanation of the problem, they were less satisfied with their visit and wanted more diagnostic tests.¹¹ Another study found that when low-risk patients were randomly assigned to a control group and received an educational intervention only, they reported equal satisfaction with their care and had clinical outcomes equal to those of the treatment group that received a plain radiograph.¹¹

Given the costs, radiation risks, and other negative aspects of unnecessary imaging, additional diagnostic tests may not be in a patient's best interest. A careful physical exam should be performed, with the clinician providing ongoing commentary to reassure patients that the clinician is neither dismissing the patient's symptoms nor inappropriately avoiding further tests.

Often, medical providers order imaging with the intention to reassure patients with the results and thus ultimately increase the patient's sense of well-being. However, the opposite effect may occur, with patients actually developing a decreased sense of wellness with no alteration of outcomes. A study evaluated general health (GH) scores (based on results from several screening questionnaires that assessed the patient's current physical and mental health state) in patients receiving MRI results.²⁰ The patients were divided into those who received results (within 48 hours), and those who did not unless it was critical to patient management (blinded group). At six weeks, the blinded group's GH score was significantly higher than the early-informed group's GH score. This suggests that receiving MRI results may negatively influence patients' perception of their general health.²⁰

The same meta-analysis that reviewed patient outcomes also evaluated mental health and quality-of-life scores of LBP patients who received either MRI, CT, or radiography.²³ There was no short-term (< 3 mo) or long-term (6-12 mo) difference between patients who received radiography versus advanced imaging. This indicates that using imaging of any kind in

patients with LBP but without indications of serious underlying conditions does not improve clinical outcomes and is negatively correlated with quality-of-life measures at short- and long-term intervals.²³

TREATMENT

The prognosis of simple acute mechanical LBP is excellent. Although back pain is a leading reason for visiting health care providers, many affected individuals never seek medical care and apparently improve on their own. In a random telephone survey of North Carolina residents, only 39% of persons with LBP sought medical care.²⁴ Therefore, patients who do seek treatment should be given reassurance, and therapies should be tailored to the individual in the least invasive and most cost-effective manner. Many treatment options are available for LBP, but often strong evidence of benefit is lacking.

Pharmacologic therapy

Anti-inflammatories. It can be assumed that when a patient comes to the practitioner for evaluation of LBP, there is an expectation that some type of medication will be recommended or prescribed for pain relief. Unless there is a contraindication, NSAIDs are often first-line therapy, and they are effective for short-term symptom relief when compared with placebo.²⁵ A mild pain medication, such as acetaminophen, is also a common treatment. The 2007 joint practice guideline from the American Pain Society (APS) and the American College of Physicians (ACP) recommends acetaminophen or NSAIDs as first-line therapy for acute LBP.³ Neither agent—NSAIDs or acetaminophen—has shown superiority, and combining the two has shown no additional benefits.²⁶ Caution must be used, however, as NSAIDs have a risk for gastrointestinal toxicity and nephrotoxicity, and acetaminophen has a dose- and patient-dependent risk for hepatotoxicity.

Muscle relaxants. Muscle relaxants are another pharmacologic treatment option for LBP. Most pain reduction from this class of medication occurs in the first one to two weeks of therapy, although benefit may continue for up to four weeks.²⁷ There is also evidence that a combination of an NSAID and a muscle relaxer has added benefits.²⁷ These medications are centrally acting, so sedation and dizziness are common; all medications in this class have these adverse effects to some degree. Carisoprodol has as its first metabolite meprobamate, which is a tranquilizer used to treat anxiety disorders; it has a potential for

abuse and should be used with caution in certain populations.

Opioids. Opioids are commonly prescribed to patients with LBP, though there are limited data regarding efficacy. One trial compared an NSAID alone versus an NSAID plus oxycodone/acetaminophen and found no significant difference in pain or disability after seven days.²⁸ In addition, the adverse effects of opioids, which include sedation, constipation, nausea, and confusion, may be amplified in the elderly population; therefore, opioids should be prescribed with caution in these patients. If prescribed to treat acute LBP, opioids should be used in short, scheduled dosing regimens since NSAIDs or acetaminophen suffice for most patients.

Corticosteroids. Oral glucocorticoids are sometimes given to patients with acute LBP, and they likely are used more frequently in patients with radicular symptoms. However, the APS/ACP 2007 joint guidelines recommend against use of systemic glucocorticoids for acute LBP due to lack of proven benefit.³ Epidural steroid injections are not generally beneficial for isolated acute LBP, but there is evidence that they are helpful with persistent radicular pain.²⁹ Zarghooni and colleagues found significant reductions in pain and use of pain medication after single-shot epidural injections.²⁹

Other pharmacologic therapies, acupuncture, sclerotherapy, and other methods are used to treat back pain, but these are typically reserved for chronic, not acute, LBP.

Nonpharmacologic therapy

Physical therapy. Physical therapy is a commonly prescribed treatment for LBP. Systematic literature reviews indicate that for patients with acute LBP (< 6 wk), there is no difference in the effectiveness of exercise therapy compared to no treatment and care provided by a general practitioner or to manipulations.³⁰ For patients with subacute (6-12 wk) and chronic (\geq 12 wk) LBP, exercise therapy is effective compared to no treatment.³⁰ There is debate, however, over which exercise activities should be used. Research supports strength/resistance and coordination/stabilization exercises.

Most therapists recommend the McKenzie method or spine stabilization exercises.³¹ The McKenzie method is used for LBP with sciatica; the patient moves through exercises within the prone position and focuses on extension of the spine. Spine stabilization is an active form of exercise based on a “neu-

tral spine” position and helps strengthen muscles to maintain this position (core stabilization). The McKenzie method, when added to first-line care for LBP, does not produce significant improvements in pain or other clinical outcomes, although it may reduce health care utilization.³² Spine stabilization exercises have been shown to decrease pain, disability, and risk for recurrence after a first episode of back pain.³³ The apparent success of physical therapy is attributed to compliance with directed home exercise programs, which have been shown to reduce the rate of recurrence, decrease episodes of acute LBP, and decrease the need for health services.³⁴

Spinal traction. Traction or nonsurgical spinal decompression has emerged as a treatment for LBP. Unfortunately, there are little data to support its use as a treatment for acute LBP. Only a few randomized trials showed benefit, and these were small studies with a high risk for bias. A Cochrane review published in 2013 looked at 32 studies involving 2,762 patients with acute, subacute, and chronic LBP.³⁵ The review did not find any evidence that traction alone or in combination with other therapy was any better than placebo treatment.³⁵

Spinal manipulation. Spinal manipulation may be more effective than placebo treatment in reducing pain when the pain has been present for less than six weeks, but it is not more effective in reducing disability.³⁶ There is little or no high-level evidence about spinal manipulation for acute LBP. However, there is some evidence of cost-effectiveness when using spinal manipulation in subacute to chronic pain.³⁷ Chiropractic techniques are considered safe (when performed by a trained provider), but a systematic review found that these techniques provide no clinically relevant improvement in pain or disability when compared to other treatments.³⁸

Bed rest. Bed rest has not been shown to improve outcomes, and in fact patients who had bed rest had less favorable outcomes than those who stayed active.³⁹ Bed rest is less effective at reducing pain and improving function when compared to staying active.³⁹

Recommended management

A patient who presents with nonspecific acute LBP should have a thorough HPE to evaluate for the presence of red flags. If no concerning findings are present, the initial visit should focus on patient education based on the following items: (1) good prognosis with little intervention, (2) staying active and avoiding bed rest as much as possible, and (3) avoid-

ing pain-causing movements when possible. The second step is to initiate a trial of an NSAID or acetaminophen and consider a muscle relaxant based on pain severity. Avoid opioid therapy if possible, but use conservative dosing if required for severe pain. Patients should be advised to return in two to four weeks if they do not experience significant improvement. At this time, the clinician may consider referring the patient for physical therapy, changing NSAIDs, ordering inflammatory markers, and/or referring to a specialist.

CONCLUSION

Although no single diagnostic protocol for LBP exists, the clinician must be able to distinguish simple from complex types. A thorough HPE is useful for categorizing the patient’s pain, with diagnostic imaging reserved for those patients with severe or progressive neurologic deficits, suspicion of serious underlying conditions, or LBP lasting more than four weeks without improvement. MRI, if available, is generally preferred over CT because it does not use ionizing radiation and provides better visualization of soft tissue, vertebral marrow, and the spinal cord. Symptomatology should be explained to patients with LBP during the HPE, with ongoing commentary to increase patient satisfaction and compliance. About two-thirds of patients with LBP do not seek evaluation from a health care provider; therefore, those who do seek treatment should be reassured, and therapies tailored to the individual in the least invasive and most cost-effective manner possible.

CR

Find the posttest for this activity at
www.clinicianreviews.com/cecme/cecme-activities.html

REFERENCES

1. CDC. National Ambulatory Medical Care Survey: 2010 Summary Tables. Table 9. www.cdc.gov/nchs/data/ahcd/namcs_summary/2010_namcs_web_tables.pdf. Accessed March 29, 2016.
2. Davies C, Nitz AJ, Mattacola CG, et al. Practice patterns when treating patients with low back pain: a survey of physical therapists. *Physiother Theor Pract*. 2014;30(6):399-408.
3. American College of Radiology. ACR Appropriateness Criteria. Low back pain. 2015. www.acr.org/~media/ACR/Documents/AppCriteria/Diagnostic/LowBackPain.pdf. Accessed March 10, 2016.
4. Henschke N, Maher CG, Ostelo RW, et al. Red flags to screen for malignancy in patients with low back pain. *Cochrane Database Syst Rev*. 2013;2:CD008686.
5. Koes BW, Tulder M, Lin CW, et al. An updated overview of clinical guidelines for the management of non-specific low back pain in primary care. *Eur Spine J*. 2010;19(12):2075-2094.
6. Deyo RA, Rainville J, Kent DL. What can the history and physical examina-

- tion tell us about low back pain? *JAMA*. 1992;268(6):760-765.
7. Jarvik JG. Diagnostic evaluation of low back pain with emphasis on imaging. *Ann Intern Med*. 2002;137:586-597.
 8. Diagnostic testing for low back pain. In: Post TW (ed), UpToDate, Waltham, MA. www.uptodate.com. Accessed March 16, 2016.
 9. Chou R, Qaseem A, Snow V, et al; Clinical Efficacy Assessment Subcommittee of the American College of Physicians; American College of Physicians; American Pain Society Low Back Pain Guidelines Panel. Diagnosis and treatment of low back pain: a joint clinical practice guideline from the American College of Physicians and the American Pain Society. *Ann Intern Med*. 2007;147(7):478-491.
 10. Deyo RA, Diehl AK. Cancer as a cause of back pain: frequency, clinical presentation, and diagnostic strategies. *J Gen Intern Med*. 1988;3(3):230-238.
 11. Deyo RA, Diehl AK. Patient satisfaction with medical care for low-back pain. *Spine*. 1986;11(1):28-30.
 12. Pradeep S, Rainville J, Katz JN, et al. The accuracy of the physical examination for the diagnosis of midlumbar and low lumbar nerve root impingement. *Spine*. 2011;36(1):63-73.
 13. Leclaire R, Blier F, Fortin L, Proulx R. A cross-sectional study comparing the Oswestry and Roland-Morris Functional Disability Scales in two populations of patients with low back pain of different levels of severity. *Spine*. 1997;22(1):68-71.
 14. FDA. Radiation emitting products. www.fda.gov/Radiation-Emitting-Products/RadiationEmittingProductsandProcedures/MedicalImaging/MedicalX-Rays/ucm115317.htm. Accessed March 29, 2016.
 15. Simpson AK, Whang PG, Jonisch A, et al. The radiation exposure associated with cervical and lumbar spine radiographs. *J Spinal Disord Tech*. 2008;21(6):409-412.
 16. Srinivas S, Deyo R, Berger Z. Application of "less is more" to lower back pain. *Arch Intern Med*. 2012;172(13):1016-1020.
 17. Webster BS, Bauer AZ, Choi Y, et al. Iatrogenic consequences of early magnetic resonance imaging in acute, work-related, disabling back pain. *Spine*. 2013;38(22):1939-1946.
 18. Webster BS, Bauer AZ, Choi Y, et al. The cascade of medical services and associated longitudinal costs due to nonadherent magnetic resonance imaging for low back pain. *Spine*. 2014;39(17):1433-1440.
 19. Liang M, Komaroff AL. Roentgenograms in primary care patients with acute low back pain: a cost-effectiveness analysis. *Arch Intern Med*. 1982;142(6):1108-1112.
 20. Ash LM, Modic MT, Obuchowski NA, et al. Effects of diagnostic information, per se, on patient outcomes in acute radiculopathy and low back pain. *AJNR Am J Neuroradiol*. 2008;29(6):1098-1103.
 21. Kendrick D, Fielding K, Bentley E, et al. Radiography of the lumbar spine in primary care patients with low back pain: randomized controlled trial. *BMJ*. 2001;322(7283):400-405.
 22. Jarvik JG, Hollingworth W, Martin B, et al. Rapid magnetic resonance imaging vs radiographs for patients with low back pain. *JAMA*. 2003;289(21):2810-2818.
 23. Chou R, Fu R, Carrino JA, Deyo RA. Imaging strategies for low-back pain: systematic review and meta-analysis. *Lancet*. 2009;373(9662):463-472.
 24. Carey TS, Evans AT, Hadler NM, et al. Acute severe low back pain: a population-based study of prevalence and care-seeking. *Spine*. 1996;21(3):339-344.
 25. Roelofs PD, Deyo RA, Koes BW, et al. Nonsteroidal anti-inflammatory drugs for low back pain. *Spine*. 2008;33(16):1766-1774.
 26. Hancock MJ, Maher CG, Latimer J, et al. Assessment of diclofenac or spinal manipulative therapy, or both, in addition to recommended first-line treatment for acute low back pain: a randomized controlled trial. *Lancet*. 2007;370(10):1638-1643.
 27. Van Tulder MW, Touray T, Furlan AD, et al. Muscle relaxants for non-specific low-back pain. *Cochrane Database Syst Rev*. 2003;(4):CD004252.
 28. Friedman BW, Dym AA, Davitt M, et al. Naproxen with cyclobenzaprine, oxycodone/acetaminophen, or placebo for treating acute low back pain: a randomized clinical trial. *JAMA*. 2015;314(15):1572-1580.
 29. Zarghooni K, Rashidi A, Siewe, J, et al. Single-shot epidural injections in the management of radicular pain. *Orthop Rev (Pavia)*. 2015;7(4):5985.
 30. Smidt N, deVet HC, Bouter LM, et al. Effectiveness of exercise therapy: A best-evidence summary of systematic reviews. *Aust J Physiother*. 2005;51(2):71-85.
 31. Casazza BA. Diagnosis and treatment of acute low back pain. *Am Fam Physician*. 2012;85(4):343-350.
 32. Machado LA, Maher CG, Herbert RD, et al. The effectiveness of the McKenzie method in addition to first-line care for acute low back pain: a randomized controlled trial. *BMC Med*. 2010;8(10):1-10.
 33. Cho I, Jeon C, Lee S, et al. Effects of lumbar stabilization exercise on functional disability and lumbar lordosis angle in patients with chronic low back pain. *J Phys Ther Sci*. 2015;27(6):1983-1985.
 34. Choi BK, Verbeek JH, Tam WW, Jiang JY. Exercises for prevention of recurrences of low-back pain (review). *Cochrane Database Syst Rev*. 2010;(1):CD006555.
 35. Wegner I, Widyahening IS, van Tulder MW, et al. Traction for low-back pain with or without sciatica (review). *Cochrane Database Syst Rev*. 2013;(8):CD003010.
 36. Hoiriis KT, Pflieger B, McDuffie FC, et al. A randomized clinical trial comparing chiropractic adjustments to muscle relaxants for subacute low back pain. *J Manipulative Physiol Ther*. 2004;27(6):388-398.
 37. Lin CC, Haas M, Maher CG, et al. Cost-effectiveness of guideline-endorsed treatments for low back pain: a systematic review. *Eur Spine J*. 2011;20:1024-1038.
 38. Walker BF, French SD, Grant W, Green S. A Cochrane Review of combined chiropractic interventions for low-back pain. *Spine*. 2011;36(3):230-242.
 39. Dahm KT, Brurberg KG, Jamtvedt G, Hagen KB. Advice to rest in bed versus advice to stay active for acute low-back pain and sciatica. *Cochrane Database Syst Rev*. 2010;(6):CD007612.
 40. Staiger T, Paauw D, Deyo A, Jarvik JG. Imaging studies for acute low back pain. When and when not to order them. *Postgrad Med*. 1999;105(4):161-162,165-166,171-172.