Appropriate Use of Lumbar Imaging for Evaluation of Low Back Pain

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KEYWORDS

- Low back pain
- Radiography
- MRI
- CT

KEY POINTS

- Strong evidence shows that routine back imaging does not improve patient outcomes, exposes patients to unnecessary harms, and increases costs.
- Diagnostic imaging studies should only be performed in patients who have severe or progressive neurologic deficits or with features suggesting a serious or specific underlying condition.
- Advanced imaging with MRI or CT should be reserved for patients with a suspected serious underlying condition or neurologic deficits or who are candidates for invasive interventions.
- To be effective, efforts to reduce imaging overuse should be multifactorial and address clinician behaviors, patient expectations and education, and financial incentives.
- Radiologists can help reduce imaging overuse by accurately reporting and providing consultative expertise regarding the prevalence and potential clinical significance (or insignificance) of imaging findings.
Low back pain is extremely common, ranking as the second most common symptomatic reason for office visits in the United States.\(^1,2\) About one-third of adults in the United States report back pain during the past 3 months,\(^3\) and nearly three-quarters of adults report at least one episode of low back pain during their lifetime.\(^3\)

Low back pain is also very costly. In 1998, total health care expenditures for individuals with back pain in the United States were estimated at $90 billion,\(^4\) and costs have since risen. The inflation-adjusted increase (in 2005 U.S. dollars) in average total health expenditures for people with back and neck problems was 65% ($4795 per year in 1997 to $6096 per year in 2005).\(^5\) Low back pain also results in high indirect costs from disability, lost time from work, and decreased productivity while at work,\(^6\) and is the most common cause for activity limitations in younger adults. In the United States, 14% of workers lose at least 1 day of work each year because of low back pain.\(^7\)

Lumbar spine imaging (plain radiography, CT, and MRI) is often performed in patients with low back pain. Although clinical practice guidelines recommend imaging only in the presence of progressive neurologic deficits or signs or symptoms suggesting a serious or specific underlying condition (the so-called red flags of low back pain),\(^8\) imaging is often performed in the absence of a clear clinical indication for it.\(^9\) This fact is concerning, because routine imaging does not seem to improve clinical outcomes, exposes patients to unnecessary harms, and contributes to the rising costs associated with low back pain.\(^10–12\)

Eliminating unnecessary tests would help rein in costs associated with low back pain while maintaining high-quality care.\(^13\) Overuse of low back imaging has long been noted as a problem,\(^14\) yet the use of imaging (particularly advanced imaging) continues to increase rapidly.\(^15\) This article reviews costs associated with spinal imaging, current imaging practice patterns and trends, evidence on benefits and harms associated with spinal imaging, factors that promote or are permissive of imaging overuse, and potential strategies for improving imaging practices.

### Costs

#### Direct Costs

Direct costs of imaging include costs of equipment and facilities, radiologic department staff, professional fees for interpreting the test, and other overhead. Because direct costs are often difficult to measure, reimbursement rates or charges are often used as surrogate measures. Although estimates vary substantially depending on geographic location, insurance status, and other factors, reimbursement rates and charges for lumbar spine CT generally run 5 to 10 times higher than lumbosacral spine plain radiography, and MRI 10 to 15 times higher (Table 1). Despite its relatively lower cost, lumbosacral spine radiography is a major contributor to costs because of its frequent use. In 2004, an estimated 66 million lumbar radiographs were performed in the United States.\(^16\)

#### Downstream Costs

In addition to direct costs, imaging can also lead to downstream cascade effects, referring to the subsequent tests, referrals, and interventions performed as a result of imaging.\(^17\) In some cases, the end result can be an invasive and expensive operation or other procedure of limited or

### Table 1

**Costs of spine imaging and fusion surgery**

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lumbar spine radiography (two or three views)(^a)</td>
<td>$54</td>
</tr>
<tr>
<td>Lumbar spine CT scan(^a)</td>
<td>$344 (without contrast)</td>
</tr>
<tr>
<td></td>
<td>$426 (with contrast)</td>
</tr>
<tr>
<td>Lumbar spine MRI(^a)</td>
<td>$645 (without contrast)</td>
</tr>
<tr>
<td></td>
<td>$794 (with contrast)</td>
</tr>
<tr>
<td>Fusion surgery(^b)</td>
<td>Without bone morphogenetic proteins: median, $57,393 (interquartile range, $39,660–$83,608)</td>
</tr>
<tr>
<td></td>
<td>With bone morphogenetic proteins: median, $74,254 (interquartile range, $54,737–$102,663)</td>
</tr>
</tbody>
</table>


\(^b\) Total charge for hospitalization, excluding professional fees, based on 2006 Nationwide Inpatient Sample data.

questionable benefit. In 2006, according to the Nationwide Inpatient Sample, the median total cost for fusion surgery without bone morphogenetic proteins was nearly $60,000, excluding professional fees.\(^{16}\) Although the increased number of unnecessary operations that occur from unneeded imaging tests is difficult to estimate, data show that rates of spine MRIs increased sharply at the same time as back surgeries.\(^{11,19}\) Similarly, over about a 10-year period starting in the mid-90s, rates of interventional procedures such as epidural steroid and facet joint injections more than tripled,\(^{20}\) a pattern that roughly parallels trends in increased use of MRI tests.

Increased use of surgery and interventional procedures would not necessarily be a problem if the procedures resulted in important clinical benefits. However, even though rates of surgery are two to five times higher in the United States than in other developed countries,\(^{21}\) no evidence shows that patients with low back pain fare better in the United States than in other countries, and randomized trials suggest that surgery and interventional procedures are associated with limited or unclear benefit in patients with nonradicular low back pain.\(^{22–24}\) In the case of spinal fusion, the widespread use of expensive add-ons, such as instrumentation and bone-morphogenetic proteins, have further increased costs, despite little evidence of improved patient outcomes, and in some cases emerging evidence of harms.\(^{18,25–27}\)

In fact, despite spending more on low back pain and performing more invasive procedures, clinical progress is difficult to discern. In adults with back or neck problems in the United States, self-reported measures of mental health, physical functioning, work or school limitations, and social limitations were all similar or poorer in 2005 compared with 1997.\(^5\) Some data suggest the situation may be getting even worse. In North Carolina, the proportion of adults reporting chronic low back pain that impaired activity more than doubled between 1992 and 2006, from 3.9% to 10.2%.\(^{28}\)

**IMAGING PRACTICES**

**Practice Variations**

Clinicians vary substantially in how frequently they obtain low back pain imaging. One study found that Medicare beneficiaries living in high-use geographic areas in the United States were more than five times more likely to undergo lumbar spine MRI and CT than if they lived in low-use areas.\(^{11}\) In addition, wide variations in diagnostic testing rates have been observed between, and within, medical specialties.\(^{29–32}\) One survey found internists almost evenly divided regarding whether they would obtain imaging for uncomplicated low back pain.\(^{30}\)

Why are practice variations a cause for concern? If they occur in otherwise similar populations and settings, variations may indicate inequalities in resource use or areas in which care is haphazard or arbitrary.\(^{33}\) In addition, research on regional variations in the United States suggests that high-use areas are generally not associated with better clinical outcomes but contribute significantly to overall healthcare costs.\(^{34,35}\) This finding often signifies inefficiencies in medical care, which can be caused by clinical uncertainty or a failure to implement evidence-based practice.

**Imaging Rates**

A study based on a national database of private insurance claims (covering 8 million beneficiaries) found that more than 40% of patients with acute low back pain underwent imaging.\(^{36}\) The median time to imaging was the same day as the index diagnosis. Data indicate that imaging rates continue to increase, despite efforts to curb overuse. An Australian study showed that imaging rates for new low back pain problems in patients seen in general practice increased slightly despite the publication of guidelines recommending against routine imaging.\(^{37}\)

**Routine Imaging**

In one survey, approximately 40% of family practice and 13% of internal medicine physicians reported ordering routine diagnostic imaging for acute low back pain.\(^{31}\) Another survey of physicians found that in the absence of any worrisome features, approximately one-quarter would order a lumbosacral spine radiograph for acute low back pain without sciatica, and about two-thirds for low back pain with sciatica.\(^{38}\) Data on actual imaging practices are consistent with the survey results. One study found that among 35,000 Medicare beneficiaries with acute low back pain and no diagnostic code indicating a serious underlying condition, nearly 30% underwent imaging (lumbar radiography or advanced imaging) within 28 days.\(^9\)

**Advanced Imaging**

Use of advanced spinal imaging is increasing rapidly. Among Medicare part B beneficiaries, the number of lumbar MRI scans performed increased approximately fourfold between 1994 and 2005 (Fig. 1).\(^{15}\) Similarly, in a large health care organization, the rate of MRIs tripled between 1997 and 2006.\(^{39}\) In North Carolina, more than one-third of patients with chronic low back pain underwent lumbar spine MRI or CT within the
past year, and other studies show even higher rates. In the emergency department setting, one recent study found that use of CT or MRI for low back pain tripled from 2002 to 2006 (3.2% vs 9.6%; \( P < .01 \) for trend). MRIs are often ordered in patients who have not undergone any treatments, despite recommendations for a trial of therapy before imaging in patients without red flags. According to Medicare’s Hospital Compare Web site, approximately one-third of Medicare patients with low back pain who underwent an outpatient lumbar spine MRI had not received any prior conservative treatment.

**EFFECTIVENESS**

The ultimate goal of any diagnostic test is to improve clinical outcomes. Most studies of diagnostic tests estimate how accurately they can identify a disease or condition, or how well the test provides prognostic information. However, even accurate tests do not necessarily result in improved patient outcomes. The ultimate effects of diagnostic testing depend on how clinicians and patients use the test results, the effectiveness of subsequent treatments, and harms related to the diagnostic test and subsequent tests and treatments. Well-conducted randomized trials are at the top of the diagnostic evidence hierarchy because they provide the most direct information about the clinical benefits and harms of alternative testing strategies. In the case of low back pain, these studies are particularly important because no adequate reference standard exists to distinguish symptomatic from asymptomatic common degenerative or age-related findings, which would be required to estimate the diagnostic accuracy of the tests for symptomatic low back pain.

Spine imaging is one of the few areas of diagnostic imaging in which multiple randomized trials reporting clinical outcomes are available. A meta-analysis of six randomized trials (n = 1804) of patients with primarily acute or subacute low back pain and no red flags found no differences between routine lumbar imaging (plain radiography, MRI, or CT) and usual care without routine imaging on measures of pain, function, quality of life, or overall patient-rated improvement (Table 2). In fact, for short-term pain, function, and quality of life, trends slightly favored usual care without routine imaging. Despite the perception that routine imaging can help alleviate patient anxiety about back pain, routine imaging also was not associated with better psychological outcomes. Patient satisfaction was reported in only a few trials and effects were mixed, with some trials showing no effect and others showing positive effects.

### Table 2

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Short-Term (&lt;3 mo) SMD</th>
<th>Long-Term (&gt;6 mo to ≤1 y) SMD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain</td>
<td>0.19 (−0.01−0.39), three trials</td>
<td>−0.04 (−0.15−0.07), four trials</td>
</tr>
<tr>
<td>Function</td>
<td>0.11 (−0.29−0.50), three trials</td>
<td>0.01 (−0.17−0.19), four trials</td>
</tr>
<tr>
<td>Quality of life</td>
<td>−0.10 (−0.53−0.34), two trials</td>
<td>−0.15 (−0.33−0.04), three trials</td>
</tr>
<tr>
<td>Mental health</td>
<td>0.12 (−0.37−0.62), two trials</td>
<td>0.01 (−0.32−0.34), three trials</td>
</tr>
<tr>
<td>Overall improvement</td>
<td>RR, 0.83 (0.65−1.06), four trials</td>
<td>RR, 0.82 (0.64−1.05), one trial</td>
</tr>
</tbody>
</table>

Abbreviations: RR, relative risk; SMD, standardized mean difference.

Data are mean SMD or point estimate for RR (95% CI). A negative SMD favors routine imaging for pain and function, whereas a positive SMD favors routine imaging for quality of life and mental health. For overall improvement, an RR <1 favors routine imaging.

that routine imaging was associated with higher satisfaction. Three of the trials restricted enrollment to patients older than 50 or 55 years, and most of the trials enrolled at least some patients with radiculopathy. The conclusions of the meta-analysis did not seem affected by whether radiography or advanced imaging (MRI or CT) was evaluated.

COST-EFFECTIVENESS

A prerequisite to evaluating the cost-effectiveness of a clinical service is to understand its clinical effectiveness. In this case, for patients with no red flags, routine imaging is no more effective than usual care without routine imaging. Performing imaging is also more expensive. Services that are more costly than the alternative, yet offer no clear clinical advantages (or do more harm than good), cannot be cost-effective, because they will always be associated with higher (or negative) cost-effectiveness ratios (in this case, the incremental cost of routine imaging compared with no routine imaging divided by the incremental clinical benefit of routine imaging compared with no routine imaging).13,48

WHY DOESN’T ROUTINE IMAGING LEAD TO BETTER CLINICAL OUTCOMES?

Favorable Natural History

In most patients with acute back pain, with or without radiculopathy, substantial improvement in pain and function occurs in the first 4 weeks, regardless of whether and how patients are treated. Routine imaging is unlikely to improve on this already favorable prognosis. Thus, the natural history of low back pain helps explain why routine imaging does not result in better clinical outcomes.

Low Prevalence of Serious Underlying Conditions

Another reason routine imaging is not beneficial is that the frequency of conditions that require urgent identification (eg, because of the potential for permanent neurologic sequelae with delayed diagnosis) is low. In patients with low back pain in primary care settings, approximately 0.7% have metastatic cancer, 0.01% spinal infection, and 0.04% cauda equina syndrome. Although vertebral compression fractures (4%) and inflammatory back disease (<1%) are more common, the diagnostic urgency for these conditions is not as great, because they are not generally associated with progressive or irreversible neurologic impairment.52,53

Studies also show that of the small proportion of patients with a serious or specific underlying condition, almost everyone will have an identifiable risk factor. In a retrospective study of 963 patients with acute low back pain, all 8 with tumors or fractures had clinical risk factors. A prospective study found no cases of cancer in 1170 patients younger than 50 years with acute low back pain and no history of cancer, weight loss, other sign of systemic illness, or failure to improve. Similarly, four trials (n = 399) that enrolled patients without risk factors and obtained imaging in all participants or recorded diagnoses through at least 6 months of clinical follow-up found that no serious conditions were missed.10

Weak Correlation Between Imaging Findings and Symptoms

Another reason that routine imaging is not beneficial is that most lumbar imaging findings are common in people without low back pain. In fact, these imaging findings are only weakly associated with back symptoms. A systematic review reported odds ratios that ranged from 1.2 to 3.3 for the association between low back pain and disc degeneration on plain radiography, and no association with spondylolisthesis (Fig. 2).56

Fig. 2. Lateral radiograph of the lumbar spine shows several common findings: (1) spondylolisthesis: grade 1 (<25%) anterolisthesis of L4 on L5 (arrows); (2) marked disc space narrowing at L4/5; (3) sclerosis of inferior end plate of L4 and superior end plate of L5; and (4) multilevel spondylosis deformans (arrowheads).
Although advanced imaging provides both increased contrast and spatial resolution compared with plain radiography, resulting in greater anatomic detail, detection of many of the findings seen on advanced imaging usually does not provide additional clinically important information. A systematic review\(^5^7\) reported odds ratios that ranged from 1.8 to 2.8 for the association between chronic low back pain and disc degeneration on MRI (Figs. 3–5), similar to the risk estimates observed in studies of plain radiography. Consistent with these findings, a randomized trial failed to show any incremental value of rapid MRI over radiography for evaluating low back pain in patients referred for imaging by their primary care physician.\(^5^8\)

In fact, most of the findings on advanced imaging are so common in asymptomatic adults that they could be viewed as normal signs of aging. In one cross-sectional study of asymptomatic persons aged 60 years or older, 36% had a herniated disc, 21% had spinal stenosis, and more than 90% had a degenerated or bulging disc.\(^5^9\) Other studies have reported similar results.\(^6^0–6^2\) Recently published studies indicate that imaging findings frequently precede symptoms, and changes on imaging do not correlate well with the clinical course. One of the few prospective studies found that among patients with documented lumbar imaging findings before the onset of low back pain, 84% had unchanged or even improved findings after symptoms developed.\(^6^3\) Another prospective study found that presence of disc protrusion on baseline MRI was a negative predictor of subsequent back pain (hazard ratio [HR], 0.5; 95% CI, 0.3–0.9) and presence of disc extrusion was not predictive (HR, 1.2; 95% CI, 0.4–3.4).\(^6^4\) Although nerve root contact and central stenosis were associated with trends
toward increased risk of future back pain (HR, 2.2; 95% CI, 0.6–8.0 and HR, 1.9; 95% CI, 0.8–4.8, respectively), the associations were not statistically significant. In fact, the only statistically significant predictor was not an imaging finding, but rather presence of depression (HR, 2.3; 95% CI, 1.2–4.4).

**Minimal Impact on Clinical Decision Making**

Back imaging also may not affect patient outcomes because results typically have no important impact on clinical decision making. Imaging studies rarely reveal unexpected findings. One review of 68,000 lumbar radiographic examinations in persons 20 to 50 years of age with low back pain estimated clinically unsuspected findings in 1 out of approximately every 2500 patients. In two studies of patients who underwent lumbar radiography (sample size approximately 100 in each), imaging affected the management plan in only 1 or 2 patients each. Similarly, a randomized trial found no differences between patients who underwent routine advanced imaging and those who did not undergo imaging in diagnosis and treatment plans. The limited therapeutic impact of routine imaging could be because the clinical significance of most imaging findings, and therefore what to do about them, is largely unknown. In fact, no evidence shows that selecting therapies based on the presence of the most common imaging findings (eg, presence of degenerative discs, facet joint arthritis, or bulging discs without nerve root compression) improves outcomes compared with a more generalized approach. Imaging findings are also a poor predictor of prognosis or response to treatment. One study found no association between the presence of common degenerative changes on MRI and outcomes after therapy.

**HARMs**

**Direct Harms**

**Radiation exposure**

Lumbar plain radiography and CT contributes to an individual’s cumulative low-level radiation exposure, which could promote carcinogenesis (Table 3). Lumbar spine CT is associated with an average effective radiation dose of 6 millisieverts (mSv). Based on the 2.2 million lumbar CT scans performed in the United States in 2007, one study projected 1200 additional future cancers. Another study estimated that cancer would be expected to occur as a result of radiation exposure in approximately 1 of every 270 women aged 40 years who underwent coronary angiography, a procedure associated with a similar average effective radiation dose compared with lumbar spine CT. In a 20-year-old woman, the estimated risk was about twice as high. Lumbar CT may also involve use of iodinated contrast, which is associated with nephropathy and hypersensitivity reactions.

Because lumbar plain radiography is performed much more frequently than lumbar CT, it accounts for a greater proportion of the total radiation dose from medical imaging procedures in the United States (3.3% vs 0.7% for lumbar CT), despite a lower average effective radiation dose (1.5 mSv). The average radiation exposure from lumbar radiography is 75 times higher than from chest radiography. This fact is of particular concern for women of child-bearing age, because of the proximity of lumbar radiography to the gonads, which are difficult to effectively shield. According to some estimates, the amount of female gonadal irradiation from lumbar radiography is equivalent to the exposure from a daily chest radiograph for several years.

**Labeling**

Spine imaging could result in unintended harms from labeling effects, which occur when patients are told that they have a condition of which they were not previously aware. A classic example of labeling was a study of blood pressure screening in steel workers in Canada, which found increased rates of absenteeism 1 year later in persons diagnosed with hypertension, particularly in persons previously unaware of their diagnosis. The authors concluded that labeling causes patients to adopt a “sick role” and treat themselves as more fragile. Similar effects may occur in patients who learn that they have findings, often described as abnormalities, on lumbar imaging. In one acute low back pain trial that performed lumbar spine MRI in all patients, those randomized to routinely receive their results reported smaller improvements in self-rated general health than

### Table 3: Average effective radiation doses

<table>
<thead>
<tr>
<th>Imaging Procedure</th>
<th>Average Radiation Dose (millisieverts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest radiograph (posterior-anterior view)</td>
<td>0.02</td>
</tr>
<tr>
<td>Lumbar spine plain radiography</td>
<td>1.5</td>
</tr>
<tr>
<td>Lumbar spine CT</td>
<td>6</td>
</tr>
<tr>
<td>Diagnostic cardiac catheterization</td>
<td>7</td>
</tr>
</tbody>
</table>

those who were blinded to the results. In another trial, patients with subacute or chronic back pain who underwent routine radiography reported more pain and worse overall health status after 3 months and were more likely to seek follow-up care than those who did not undergo radiography. Knowledge of clinically irrelevant imaging findings might hinder recovery by causing patients to worry more, focus excessively on minor back symptoms, or avoid exercise and other recommended activities because of fears that they could cause more structural damage, a pattern of maladaptive coping referred to as fear avoidance. These behaviors are associated with the development of chronic low back pain, can be difficult to change, and may be insidious, affecting patients even when they are not consciously aware of them. These potential harms emphasize the need for imaging professionals to choose descriptive language with care, and to recognize their obligation to educate referring physicians and patients regarding the insignificance of age-related imaging findings.

Downstream Harms

Association between imaging and surgery

Despite all of the uncertainties related to the interpretation of imaging tests, patients and clinicians frequently view findings on imaging as targets for surgery or other procedures. In fact, the association between rates of advanced spine imaging and rates of spine surgery is strong. One study showed that variation in rates of spine MRI use accounted for 22% of the variability in overall spine surgery rates in Medicare beneficiaries, or more than double the variability accounted for by differences in patient characteristics. In one study, patients randomized to rapid MRI had twice the number of lumbar operations as those receiving plain radiographs, although small numbers made the difference only marginally statistically significant. Another study found that for work-related acute low back pain, MRI within the first month was associated with a more than eightfold increase in risk for surgery and more than a fivefold increase in subsequent total medical costs compared with propensity-matched controls who did not undergo early MRI.

WHY ISN’T CURRENT PRACTICE CONSISTENT WITH THE EVIDENCE?

Patient Expectations

One reason that current practice is not consistent with the evidence is patient expectations. Patients want a specific diagnosis to explain their symptoms. In addition, patients may equate a decision to not obtain imaging or provide a precise diagnosis with low-quality or suboptimal care, or interpret the decision to not perform imaging as implying that their pain is not legitimate or important. In patients with chronic back pain, the desire for diagnostic tests is a frequent reason for repeat office visits. Patient preferences about diagnostic testing seem to be communicated to physicians, who frequently accede to patient desires or requests for imaging. In one study, an increased likelihood of obtaining low back pain imaging was strongly associated with how intensely patients believed imaging was necessary. A survey of physicians in the United States showed that over one-third would order a lumbar MRI for uncomplicated acute low back pain if a patient insisted on it, even after explaining that it was unnecessary.

Imaging decisions may themselves affect patient expectations, because those who undergo imaging for one episode of low back pain may come to expect it for future episodes. One trial showed that patients randomized to routine imaging became more likely to believe it was necessary compared with those randomized to an educational intervention without routine imaging, despite no beneficial effects on clinical outcomes.

Financial Incentives

Financial incentives can influence imaging decisions. For example, performance incentives may be linked to markers of patient satisfaction. At the same time, performing more imaging tends to be associated with higher patient satisfaction. Randomized trials show that patients express more satisfaction with their care when they undergo routine lumbar imaging compared with no routine imaging, and when they undergo advanced imaging instead of radiography, even when their clinical outcomes are no better. A study of Medicare beneficiaries found earlier use of imaging and more advanced imaging when clinician incentives were based on patient satisfaction. Therefore, financial incentives based on patient satisfaction can encourage overuse of imaging.

From a health systems perspective, financial incentives may exist for using imaging units. A top-of-the-line MRI unit can cost $2 million or more to purchase, and approximately $800,000 a year to operate. At the same time, advanced imaging offers a high profit margin. Relative to actual costs, Medicare provides far greater reimbursement for MRI (reimbursement-to-cost ratio, 2.3) than for conventional radiography (reimbursement-to-cost ratio, 0.9).
Research shows that greater availability of imaging units seems to correlate with increased use. The number of MRI scanners in the United States more than tripled from 2000 to 2005, from 7.6 to 26.6 per million people. In 2006, about 7000 sites in the United States offered MRI studies, which translates into a number of MRIs per capita almost twice as high as in any other industrialized country, and more than four times as high as in Canada or the United Kingdom. In 2006, estimates showed that almost as many MRI machines were available in western Pennsylvania (N = 140) as in all of Canada (N = 151). One study found that each new MRI unit added within a geographic area was associated with approximately 40 additional lumbar MRIs over a 5-year period.

Imaging self-referral, or acquisition of imaging equipment and billing for imaging tests by non-radiologist physicians, is also associated with increased imaging use. A 2009 report from the Medicare Payment Advisory Commission found physician ownership or investment in imaging facilities associated with higher use rates after adjustment for potential confounders. A study of Medicare claims found that acquisition of MRI equipment by primary care physicians increased MRI use rates from 11% to 17% (P < .001) in the following 180 days. In orthopedic surgery practices, the MRI rates increased from 22% to 27% (P < .001). An earlier study of workman’s compensation cases found more inappropriate imaging requests when physicians self-referred.

Defensive Medicine

Overuse of back imaging could also be related to perceived liability risks of missing a serious diagnosis. “Defensive medicine” refers to the alteration of clinical behavior because of concerns over malpractice liability. Inappropriate imaging seems to be a very common form of defensive medicine. In one study, more than 90% of physicians from six specialties in Pennsylvania reported defensive medicine practices. Almost half of those with positive responses reported use of imaging in clinically unnecessary circumstances as their most recent defensive act. Defensive medicine practices are probably more likely when there is a higher likelihood (or a perceived higher likelihood) of a legal claim related to the back pain, or when patients express dissatisfaction. Low back pain imaging is often a routine part of the evaluation in workman’s compensation and disability cases, despite the absence of evidence that it improves outcomes in these settings.

Time

Another reason that back imaging is overused may be that clinicians are frequently overworked and pressed for time, and ordering an imaging test seems more expedient than explaining why imaging is not necessary. In patients who have strong notions about the need for back imaging, the perceived (or real) time savings may be particularly high.

RECOMMENDATIONS ON IMAGING USE

When to Image

Routine imaging in low-risk patients does not improve patient outcomes but increases costs and exposes patient to harms, including unnecessary radiation exposure and invasive treatments, and the deleterious effect of likely labeling that person as a patient with a degenerative spinal disorder. Several professional societies have issued practice guidelines and standards to help address overuse of low back imaging. In 2007, the American College of Physicians (ACP) and the American Pain Society (APS) published a joint clinical practice guideline on diagnosis and treatment of low back pain. The key recommendations regarding diagnostic imaging were:

- Do not routinely obtain imaging or other diagnostic tests in patients with nonspecific low-back pain
- Perform diagnostic imaging and testing when severe or progressive neurologic deficits are present or when serious underlying conditions are suspected
- Evaluate patients with persistent low back pain and signs or symptoms of radiculopathy or spinal stenosis who are candidates for surgery or epidural steroid injection.

In 2009, the American College of Radiology published consensus-based criteria on appropriateness of imaging for various low back pain scenarios that were largely consistent with the ACP/APS guidelines. For uncomplicated low back pain with or without radiculopathy, imaging was deemed inappropriate in the absence of the following red flags:

- Recent significant trauma or milder trauma at age older than 50 years
- Unexplained weight loss
- Unexplained fever
- Immunosuppression
- History of cancer
- Intravenous drug use
- Prolonged use of corticosteroids or osteoporosis
- Age older than 70 years
- Focal neurologic deficit with progressive or disabling symptoms
- Duration longer than 6 weeks.

Subsequently, the ACP published more detailed guidance on use of lumbar imaging (Table 4). All of the guidelines are consistent in recommending immediate imaging in patients with signs, symptoms, or risk factors for cauda equina syndrome or vertebral infection. Although these conditions are rare, the prevalence of suggestive findings or risk factors for them is low and timely diagnosis and treatment may prevent serious sequelae related to compression of the spinal cord (which typically ends at the L1 or L2 level) or cauda equina. Clinical findings for cauda equina syndrome or vertebral infection include new

<table>
<thead>
<tr>
<th>Imaging Action</th>
<th>Suggestions for Initial Imaging</th>
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<tbody>
<tr>
<td>Immediate imaging</td>
<td>Major risk factors for cancer (new onset of low back pain with history of cancer, multiple risk factors for cancer, or strong clinical suspicion for cancer)</td>
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<tr>
<td>Radiography (with erythrocyte sedimentation rate)</td>
<td>Risk factors for spinal infection (new onset of low back pain with fever and history of intravenous drug use or recent infection)</td>
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<tr>
<td>MRI</td>
<td>Risk factors for or signs of cauda equina syndrome (new urinary retention, fecal incontinence, or saddle anesthesia)</td>
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<tr>
<td>MRI</td>
<td>Severe neurologic deficits (progressive motor weakness or motor deficits at multiple neurologic levels)</td>
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<tr>
<td>Defer imaging after a trial of therapy</td>
<td>Weaker risk factors for cancer (unexplained weight loss or age &gt;50 y)</td>
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<tr>
<td>Radiography (with or without erythrocyte sedimentation rate)</td>
<td>Risk factors for or signs of ankylosing spondylitis (morning stiffness that improves with exercise, alternating buttock pain, awakening because of back pain during the second part of the night, or younger age [20–40 y])</td>
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<tr>
<td>MRI</td>
<td>Risk factors for vertebral compression fracture (history of osteoporosis, use of corticosteroids, significant trauma, or older age (&gt;75 y for men or &gt;65 y for women))</td>
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<tr>
<td>MRI</td>
<td>Signs and symptoms of radiculopathy (back pain with leg pain in an L4, L5, or S1 nerve root distribution or positive result on straight leg raise or crossed straight leg raise test) in patients who are candidates for surgery or epidural steroid injection</td>
</tr>
<tr>
<td>MRI</td>
<td>Risk factors for or symptoms of spinal stenosis (radiating leg pain, older age, or pseudoclaudication) in patients who are candidates for surgery</td>
</tr>
<tr>
<td>No imaging</td>
<td>No criteria for immediate imaging and back pain improved or resolved after a 1-month trial of therapy</td>
</tr>
<tr>
<td>No imaging</td>
<td>Previous spinal imaging with no change in clinical status</td>
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urinary retention, saddle anesthesia, fecal incontinence, or fever (especially in patients with risk factors for bacteremia). Urinary retention is the most common finding for cauda equina syndrome. Without urinary retention, the likelihood of cauda equina syndrome is on the order of 1 in 10,000. Imaging is also recommended for patients with severe or progressive neurologic deficits, defined as objective motor weakness at a single level, or deficits at multiple spinal levels.

In patients with findings or risk factors for other specific conditions, such as cancer (age >50 years, failure to improve after 1 month, weight loss), vertebral compression fracture (older age, history of or risk factors for osteoporosis, significant trauma), ankylosing spondylitis (morning stiffness, improvement with exercise, younger age, chronic symptoms), herniated disc (radiculopathy, positive straight leg raise), or symptomatic spinal stenosis (older age, leg pain, pseudoclaudication), optimal diagnostic strategies are less clear. The traditional recommendation has been to act on all risk factors by obtaining imaging. However, the low frequency of these conditions and the low specificity of most risk factors would result in high imaging rates with low positive predictive values. For example, one study of 1172 consecutive patients with acute back pain presenting to primary care found that approximately one-quarter were older than 55 years, approximately one-quarter had morning back stiffness, and approximately one-third had pain that improved with exercise. All of these are considered risk factors for cancer or inflammatory back pain, but no cases of cancer and only two inflammatory conditions were identified in this cohort.

A more efficient strategy proposed by the ACP is to perform imaging based on the estimated prevalence of the condition before risk factor assessment (the pretest probability) and how strongly the risk factors predict the condition (Table 5). For instance, the prevalence of cancer in a primary care population is approximately 0.7%. A previous history of cancer (not including nonmelanoma skin cancer) is the strongest risk factor for spinal tumor (positive likelihood ratio, 15). Unexplained weight loss, failure to improve after 1 month, and age older than 50 years are weaker risk factors (positive likelihood ratio, 2.7–3.0). Based on these likelihood ratios, the probability of cancer if a history of prior cancer is present would increase to approximately 9%, or high

<table>
<thead>
<tr>
<th>Step</th>
<th>Example: 57-Year-Old Man Presents to Primary Care Clinic with 3 Days of Acute Low Back Pain</th>
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<tbody>
<tr>
<td>1.</td>
<td>Estimate the pretest probability of persistent low back pain (the probability before assessing for risk factors)</td>
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<tr>
<td></td>
<td>A study of patients seen in a primary care clinic estimated an overall prevalence of low back pain of 0.7%</td>
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<tr>
<td>2.</td>
<td>Convert the pretest probability to pretest odds</td>
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<tr>
<td></td>
<td>Pretest probability for cancer = 0.7% or 7/1000; pretest odds = 7/(1000–7) = 7/993</td>
</tr>
<tr>
<td>3.</td>
<td>Determine which risk factors for cancer are present, and the associated likelihood ratio</td>
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<tr>
<td></td>
<td>Example A: assume that the patient has a personal history of prostate cancer; the likelihood ratio for spinal tumor in persons with such a history is 15</td>
</tr>
<tr>
<td></td>
<td>Example B: assume that the patient has no risk factors for cancer other than age &gt;50 y; the likelihood ratio for spinal tumor in patients aged &gt;50 years is 2.7</td>
</tr>
<tr>
<td>4.</td>
<td>Multiple the pretest odds by the likelihood ratio to determine the posttest odds</td>
</tr>
<tr>
<td></td>
<td>Example A: posttest odds for spinal tumor = 7/993 × 15 or 105/993</td>
</tr>
<tr>
<td></td>
<td>Example B: posttest odds for spinal tumor = 7/993 × 2.7 or 19/993</td>
</tr>
<tr>
<td>5.</td>
<td>Convert the posttest odds to posttest probability</td>
</tr>
<tr>
<td></td>
<td>Example A: posttest probability for spinal tumor = 105/(105 + 993) = 105/1098 = 9.6%</td>
</tr>
<tr>
<td></td>
<td>Example B: Posttest probability for spinal tumor = 19/(19+993) = 19/1012 = 1.9%</td>
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</tbody>
</table>

* Converting probability to odds: probability x/y = odds x/(y – x).
* Converting odds to probability: odds x/y = probability x/(x + y).
enough to warrant immediate imaging (a strong clinical suspicion for cancer would give a similar result). 94 In patients with any one of the other three risk factors, the posttest probability only increases marginally, to 1% to 2%. 55 Deferring imaging would be reasonable in most cases, unless symptoms fail to improve after several weeks. 54,96 For patients without signs of neurologic compromise but with minor risk factors for vertebral compression fracture, ankylosing spondylitis, herniated disc, or spinal stenosis, a trial of therapy before imaging is also warranted according to the ACP criteria, because delaying imaging in these circumstances is unlikely to result in missed therapeutic opportunities. For herniated disc or spinal stenosis, none of the trials showing benefits of surgery have enrolled patients with fewer than 6 to 12 weeks of symptoms, and no serious neurologic complications were seen among patients not randomized to immediate surgery. 97–100 Diagnostic rules based on the evaluation of multiple risk factors could help better inform imaging decisions but require further development. For vertebral compression fracture, one study evaluated a diagnostic rule based on four risk factors (female sex, age >70 years, significant trauma, or prolonged use of corticosteroids). 94 It found a likelihood ratio of 1.8 (95% CI, 1.1–2.0) if one of four risk factors was present, and 15 (95% CI, 7.2–25) if two or more were present. However, these rules require more external validation before they can be recommended for general use.

Choice of Imaging Procedure

The ACR appropriateness criteria recommend lumbar plain radiography for the initial evaluation of low back pain in patients with recent trauma or history of osteoporosis, and in persons aged 70 years or older, 92 which is consistent with ACP recommendations 93 on imaging. Both societies recommend lumbar spine and pelvis plain radiography for evaluation of suspected ankylosing spondylitis. 92,93 Both also recommend that advanced imaging be reserved for situations in which findings are more likely to influence clinical decision making, as in patients with major trauma or severe neurologic compromise (objective or progressive motor weakness, deficits at multiple levels, or suspected cauda equina syndrome) and in those with risk factors for vertebral infection. 93 When cancer is not strongly suspected and in the absence of neurologic signs, obtaining initial imaging with lumbar radiography plus an erythrocyte sedimentation rate is a reasonable approach, 96 although advanced imaging may be appropriate when high clinical suspicion persists despite initial negative tests. For persistent radicular symptoms or spinal stenosis without severe neurologic compromise, advanced imaging should be performed after at least a 1-month trial of therapy if patients are interested in and candidates for surgery or an epidural steroid injection. 8

Repeat Imaging

Repeat back imaging is common. In one study of patients with low back pain in North Carolina who had received an MRI or CT of the back, more than half reported a second advanced imaging test within the previous year. 40 Although evidence on the effects of repeat imaging on patient outcomes is not available, prospective studies of repeat imaging indicate that new MRI findings are uncommon. 60,63 Rather, typical findings are progression of already identified degenerative changes and, in some cases, improvement and regression over time. Therefore, periodically performing repeat imaging on a routine basis is extremely unlikely to be an effective or informative approach. Rather, repeat imaging should only be performed for new or changed clinical features, such as acute or progressive neurologic symptoms or recent trauma.

Patient Education

Patient expectations regarding back imaging are frequently discordant with the evidence. 79 However, most patients do not want tests that are unnecessary, costly, or potentially harmful. The ACP guidelines recommend education to help bring patient expectations more in line with the evidence. 93 Explaining that risk factor assessment is sensitive for identifying worrisome conditions such as cancer or infection, acute low back pain is highly likely to improve in the first 4 weeks, and imaging can be performed later if symptoms fail to improve may help reassure some patients that they have been appropriately assessed and that the problem is not being simply dismissed. In fact, effective education may be less burdensome than often assumed. One randomized trial found that a brief educational intervention regarding back imaging took less than 5 minutes and resulted in similar patient satisfaction with overall care (and similar clinical outcomes) compared with routinely performing lumbar spine plain radiography. 83 Supplementing face-to-face information with patient handouts, self-care education books, 101 online materials, 93 or other methods could be an efficient strategy to reinforce or expand on key educational points.
**Effecting Change**

Changing clinician behaviors is challenging. In general, research suggests that active and individualized methods are more effective for changing clinician behaviors than passive ones, such as simply providing guidelines. Similarly, a systematic review of interventions for increasing appropriate low back pain imaging found varying effects from distribution of educational materials. Prior authorization requirements for advanced spine imaging have been imposed by many health insurers and are more effective at reducing inappropriate imaging than more passive approaches, but are often viewed as onerous by physicians. As a potentially more acceptable alternative, one randomized trial found that an intervention consisting of an educational session by local clinical leaders followed by clinician audit and feedback was more effective than no intervention for reducing inappropriate lumbar imaging. Another promising method is computer-based decision support that provides information at the time of ordering, such as whether the patient has undergone a recent imaging study, and compares ordering patterns to those of peers. Radiologists could play an important role in making decision support effective through providing mandatory consultation when provider requests for imaging are inconsistent with guidelines. One retrospective study showed that one-quarter of imaging requests for MRI or CT were inappropriate and could have potentially been avoided with decision support, including radiology consultation. A prerequisite, of course, is that radiologists must be familiar with and able to discuss guideline recommendations with referring physicians.

The most effective interventions for reducing inappropriate imaging may be multifactorial. One study found that implementing an intervention that included a requirement for providers to identify an approved lumbar imaging indication before ordering an advanced imaging study, institutional education programs on appropriate imaging, periodic audits and feedback for providers who ordered imaging tests inconsistent with the criteria, and availability of same- or next-day physical therapy and consultation for patients in whom imaging was not indicated reduced the rate of lumbar MRI for low back pain by 23% (relative risk, 0.77; 95% CI, 0.67–0.87). When imaging tests are performed, radiologists play an important role in how findings are communicated. For example, describing uncomplicated degenerative findings as common or incidental age-related phenomena rather than as abnormalities could potentially reduce labeling effects and unnecessary downstream testing and treatments. Conversely, the liberal application of terms such as herniation to small or trivial intervertebral disc findings that are unlikely to be clinically relevant may imply a diagnosis that supports surgical interventions. One study found inclusion of an epidemiologic statement in lumbar imaging reports describing the prevalence of common findings on lumbar spine MRI in asymptomatic adults was associated with a trend toward decreased likelihood of repeat imaging (odds ratio [OR], 0.21; 95% CI, 0.03–1.7) and decreased the likelihood of opioid prescription use (OR, 0.29; 95% CI, 0.11–0.77), although no difference was seen in the rate of surgical consultations or surgeries. Studies show that primary care clinicians prefer a more active role from radiologists in interpreting imaging findings, such as radiology reports that include management recommendations, such as suggestions for potential treatments and referrals. Additional research is needed to understand effective methods for accurately describing imaging findings, their potential clinical significance, and appropriate management options.

Efforts to decrease inappropriate imaging must also address financial incentives that influence overuse. For example, clinician incentive programs that are based on patient satisfaction may have a tendency to reward unnecessary testing and therefore be counterproductive. Rather, financial incentives should be based on how well clinicians adhere to guidelines. Other efforts to curb overuse include payment reductions by Medicare to limit rewards for imaging self-referral, and federal legislation mandating disclosure of physician ownership interests.

**SUMMARY**

Strong evidence shows that routine back imaging does not improve patient outcomes, exposes patients to unnecessary harms, and increases costs. However, imaging practices remain inconsistent with evidence-based guidelines and use continues to rise. Diagnostic imaging studies should only be performed in selected higher-risk patients who have severe or progressive neurologic deficits or are suspected of having a serious or specific underlying condition, and advanced imaging with MRI or CT should be reserved for patients with a suspected serious underlying condition or neurologic deficits, or who are candidates for invasive interventions. To be most effective, efforts to reign in imaging should be multifactorial and address clinician behaviors,
patient expectations and education, and financial incentives. Radiologists can play a critical role in these efforts through providing consultative expertise in decision support programs related to appropriateness of imaging requests, and accurately reporting the prevalence and potential clinical significance (or insignificance) of imaging findings.

REFERENCES

29. Carey BS, Garrett J. Patterns of ordering diagnostic tests for patients with acute low back pain. The


