RATIONAL IMAGING

Low back pain in primary care

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A woman aged 71 with smoking related lung disease and frequent use of corticosteroids presented to clinic with acute severe low back pain. The pain began yesterday after she moved furniture in her apartment, is centrally located in the upper lumbar region without radiation to the legs, and is worse with movement. On examination, she has tenderness to palpation over the upper lumbar spine.

What is the next investigation?

Many observers argue that lumbar spine imaging is overused in developed countries because of a low yield of clinically useful findings, a high yield of misleading findings, radiation exposure (especially to the gonads), and costs. This is a particular concern in the United States, where imaging capacity is high, and spine specialists commonly have their own imaging facilities. These concerns are valid, despite the broad differential diagnosis of back pain, which includes not only degenerative changes but deformity, fracture, and underlying systemic diseases such as malignancy, infection, or ankylosing spondylitis. Though metastatic cancer might be the most common of these systemic conditions, its prevalence in primary care patients with back pain is less than 1%.1

In the absence of neurological symptoms, the main reason to consider early lumbar imaging is to identify serious underlying systemic disease or fractures. Fortunately, these are rare, though their prevalence varies with age, sex, and clinical presentation. In the case presented here, the patient’s age, sex, smoking status, and use of corticosteroids render her at high risk for an osteoporotic vertebral compression fracture.1 The acute onset, localized nature, and aggravation with movement are consistent with a diagnosis of fracture. In the United Kingdom, the National Institute for Health and Care Excellence (NICE) recommends “consideration of MRI” when fracture is suspected.4 Guidelines from the American College of Physicians recommend plain radiography for patients with risk factors for vertebral compression fracture but only after a therapeutic trial (table 1).3 In this case, because of multiple risk factors for fracture, a compromise would be early radiography, which could confirm the diagnosis, prompt appropriate treatment to reduce the risk of future fractures, and raise the possibility of treatment with calcitonin for acute pain.4 Radiography confirmed the diagnosis of compression fracture (fig 1).

Imaging for neurological symptoms

The presence of severe neurological symptoms, such as urinary retention, saddle anesthesia, or severe or progressive motor deficits would raise the possibility of massive disc herniation, tumor, or displaced fracture fragment causing cauda equina syndrome or compression of the cord. Guidelines in both the UK and the US suggest these rare findings are indications for advanced

KEY POINTS

- Imaging of the lumbar spine for low risk patients can be overused given its low yield of useful findings, high yield of misleading findings, and lack of proved benefit for outcome
- Radiography (with or without erythrocyte sedimentation rate) is often an appropriate initial test for suspected cancer, fracture, or inflammatory spondylolysis
- MRI is appropriate for patients with major neurologic deficits. It is also appropriate for those with a clinical picture of sciatica or stenosis who fail to improve with a therapeutic trial and are potential candidates for surgery or epidural steroids
- Patient histories of cancer, injection drug use, major trauma, or prolonged corticosteroid use are important “red flags” to prompt imaging; other individual red flags have weak likelihood ratios, and the full clinical picture should guide the ordering of lumbar images

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Previous articles in this series

- Investigating stable chest pain of suspected cardiac origin (BMJ 2013;347:f3940)
- Investigating suspected scaphoid fracture (BMJ 2013;346:f1370)
- Suspected left sided diverticulitis (BMJ 2013;346:f928)
- Investigating pleural thickening (BMJ 2013;346:e8376)
- Investigating urinary tract infections in children (BMJ 2013;346:e8654)
cross sectional imaging: magnetic resonance imaging (MRI) where available or computed tomography (CT) where it is not. Minor neurologic findings are more common. A herniated disc causing radiculopathy might result in symptoms of sciatica, limited straight leg raising, a missing deep tendon reflex, or mild foot weakness in dorsiflexion or planatar flexion. Spinal stenosis would be suspected in an older adult with radiating leg pain or pseudoclaudication.

In these circumstances, guidelines from the American College of Physicians (table 1) recommend a one month trial of treatment before imaging because most patients with acute back pain and radiculopathy improve substantially in that interval without invasive interventions and imaging would not alter initial management. If patients have not improved after a month, and interventions such as surgery or epidural steroid injections are considered, advanced imaging is indicated (figs 2 and 3). The NICE guidelines do not refer to imaging for these milder neurologic findings.

**Risks of unnecessary imaging**

Clinicians and patients alike might imagine no harm in a non-invasive imaging test. In the case of spine imaging, however, there is a substantial risk of uncovering irrelevant and misleading findings. For example, in a study of 98 MRIs from pain-free volunteers (mean age 42), only 36% had normal discs at all levels. Over half had a bulging disc, and 27% had a protruded disc. Annular fissures were found in 14% and facet arthropathy in 8%. A prospective study of 200 individuals who initially had no back pain showed that imaging abnormalities often preceded development of back pain. Among the 25% who developed back pain over five years, most MRI findings were unchanged or even improved. Plain radiography and computed tomography similarly show frequent “abnormalities” in pain-free individuals. Both a randomized trial and observational studies suggest that such findings can lead to more surgery and more aggressive treatment, without improvements in patient outcomes. In studies of geographic variations in care, rates of spinal surgery are higher where MRI rates are higher.

Knowing about an imaging abnormality might have adverse effects on patient self perceptions and behavior. In a randomized trial, low risk patients who underwent plain lumbar radiography reported worse pain and overall health during follow-up than those who had no imaging. They also sought more medical care. Similarly, in a trial of lumbar MRI, patients were randomized to receive the report or not. Although clinical outcomes were the same for the two groups, those who did not receive results reported greater improvements in general health. Thus, spinal imaging in low risk patients might diminish self perceived health and drive unnecessary visits and surgery.

Radiation exposure is a concern for plain radiography and computed tomography. Unlike chest radiography, lumbar spine films result in substantial irradiation of the gonads, slightly increasing both mutagenesis and carcinogenesis. Computed tomography results in higher radiation exposure than radiography. In the US, an annual 2.2 million lumbar scans are projected to result in an additional 1200 future cases of cancer. Because of reproductive concerns and the time required for cancer to develop, radiation risks are more important in younger than in older patients.

**Impact of imaging on patient outcomes**

The ultimate confirmation of the value of a diagnostic test is that it improves patient outcomes, presumably by guiding better treatment. Though randomized trials of diagnostic tests are rare, we identified six randomized trials of some form of lumbar spine imaging compared with usual care without imaging for low risk patients. In pooled analyses, the use of imaging was not associated with any advantage in pain relief or functional recovery, in either the short term (<3 months) or the longer term (6 months to a year).

**Strategies for selective ordering of lumbar images**

Given the limitations of spinal imaging, several guidelines have recommended highly selective use. The NICE guideline recommends serial clinical review of the diagnosis; no radiography for non-specific low back pain; and consideration of MRI when malignancy, infection, fracture, cauda equina syndrome, or ankylosing spondylitis is suspected (table 1). The clinical challenge is to decide when suspicion of these conditions is sufficiently high to warrant imaging.

Some studies and guidelines have proposed the use of “red flags” to guide selective ordering of lumbar images or
Red flags for cancer

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Positive likelihood ratio</th>
<th>Negative likelihood ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>History of cancer</td>
<td>0.31</td>
<td>0.98</td>
<td>15.3</td>
<td>0.70</td>
</tr>
<tr>
<td>Age &gt;50</td>
<td>0.77</td>
<td>0.71</td>
<td>2.7</td>
<td>0.32</td>
</tr>
<tr>
<td>Unexplained weight loss</td>
<td>0.15</td>
<td>0.94</td>
<td>2.6</td>
<td>0.90</td>
</tr>
<tr>
<td>Not improved after 1 month</td>
<td>0.31</td>
<td>0.90</td>
<td>3.0</td>
<td>0.77</td>
</tr>
</tbody>
</table>

Test accuracy for cancer

- ESR ≥20 mm/h: Sensitivity 0.78, Specificity 0.67, Positive likelihood ratio 2.4, Negative likelihood ratio 0.33
- ESR ≥50 mm/h: Sensitivity 0.56, Specificity 0.97, Positive likelihood ratio 18.7, Negative likelihood ratio 0.45
- Plain radiography: Sensitivity 0.6, Specificity 0.95-0.995, Positive likelihood ratio 12-120, Negative likelihood ratio 0.40-0.42
- MRI: Sensitivity 0.83-0.93, Specificity 0.90-0.97, Positive likelihood ratio 8.3-31, Negative likelihood ratio 0.07-0.19

Red flags for spinal fracture

- Age >70: Sensitivity 0.22-0.50, Specificity 0.96, Positive likelihood ratio 5.5-11.2, Negative likelihood ratio 0.52-0.81
- Use of corticosteroids: Sensitivity 0.06-0.25, Specificity 0.995, Positive likelihood ratio 12.48, Negative likelihood ratio 0.75-0.94
- Significant trauma: Sensitivity 0.25-0.30, Specificity 0.85-0.98, Positive likelihood ratio 2.0-10, Negative likelihood ratio 0.77-0.82

ESR=erythrocyte sedimentation rate; MRI=magnetic resonance imaging.

Table 2 | Estimates of diagnostic performance for selected “red flag” clinical findings and selected diagnostic tests in detecting spinal malignancy or fracture. Spinal malignancy is the most common underlying systemic cause of back pain. Estimates are based on samples from primary care.1 5 16-18

Fig 2 | MRI from man in his 40s with persistent back and leg pain. Sagittal T2 weighted image shows a disc extrusion at L5-S1 extending inferiorly from level of interspace (black arrow) (a). Axial image shows that disc (long white arrow) is compressing right S1 nerve root (short gray arrows) in lateral recess (b)

Fig 3 | MRI from middle aged man with metastatic lung cancer, with new hip pain radiating to ankle. Sagittal T2-weighted image shows pathological fracture of L5 with hypointense tumor diffusely infiltrating the normal hyperintense marrow (white arrows) (a). Axial T2 weighted image shows extension of tumor posteriorly into lateral recess (white arrows) with presumptive compression of right S1 nerve root (b)

to minimize the use of advanced imaging. Red flags are a history or findings on physical examination that suggest an increased probability of underlying systemic disease, fracture, or neurologic injury—conditions that might influence initial treatment. They typically include factors such as a history of cancer, a history of injecting drug use, advanced age (variably defined), major trauma, use of corticosteroids, and severe or progressive neurologic deficit. Some lists include a wider range of findings, such as limited straight leg raising, abnormal reflexes, spine tenderness, unexplained weight loss, and others.5

The prevalence of serious spine disorders is low and the sensitivity and specificity of most red flags modest (table 2).1 5 16 As a result, recent studies have highlighted the limited predictive value of most red flags and suggested that performing imaging with the presence of any red flag would result in unnecessarily high rates of imaging.16 Observers have therefore suggested that use of imaging should be guided by the full clinical picture and observation over time, rather than by uncritical use of individual red flags.17 Indeed, the predictive value of individual red flags varies substantially, and the presence of multiple red flags generates higher predictive values.1 5 On the other hand, clinicians sometimes fail to assess major risk factors that should prompt early imaging, such as a history of cancer or injecting drug use, so some guidance seems appropriate.

One inexpensive strategy to augment the sensitivity and specificity of clinical assessment is the use of an inflammatory marker such as the erythrocyte sedimentation rate (ESR), which is often higher in patients with cancer, infections, or inflammatory spondylopathies. This has been incorporated into guidelines from the American College of Physicians (table 1).2 Though the erythrocyte sedimentation rate is non-specific, its use in this context, combined with plain radiography, is mainly intended to help “rule out” underlying systemic disease without resorting to advanced imaging. A cost effectiveness analysis suggested that a reasonable strategy is to use advanced imaging only for patients with a red flag plus either an erythrocyte sedimentation rate ≥50 mm/h or a positive result on radiography.18

Additional opportunities to reduce unnecessary spinal imaging include efforts to eliminate repeated testing, potentially with reminders of recent imaging through the use of electronic health records. Another strategy is to alert primary care clinicians about the dubious clinical importance of some degenerative findings on imaging by pointing out their high prevalence in pain-free individuals. A small observational study suggested that adding such a message to routine MRI reports could reduce the use of subsequent imaging tests.19

Factors promoting unnecessary spinal imaging

Many patients are eager for an explanation of their symptoms and expect imaging when they have back pain. In some studies, patients report higher satisfaction with care for back pain if imaging is performed than if it is not or if more advanced imaging is performed than radiography.17-12 Studies of insurance claims in the US suggest that clinicians order earlier and more advanced imaging when they have...
financial incentives based on patient satisfaction questionnaires. Patient education strategies might mitigate the impact of delayed or no imaging on patient satisfaction.

Financial incentives are also important when there is high imaging capacity and referral to self owned imaging facilities. Both are concerns in the US, and the former might become increasingly important in the UK if commercialization of the National Health Service increases access to advanced imaging. Advanced imaging such as MRI offers a relatively high profit margin in the US. Finally, physicians are often concerned about legal liability if a serious diagnosis such as cancer or infection is delayed.

Outcome
The full clinical picture in this case prompted early radiography. The patient’s L1 compression fracture was readily apparent on radiography, as was the suggestion of osteopenia. There was no indication of metastatic disease to suggest a pathologic fracture related to malignancy. The patient was treated with oral analgesics, and her symptoms were substantially improved at six weeks’ follow-up. At that point, she was started on treatment with bisphosphonates, with the goal of reducing risk of further fracture.

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Avoid surgery as first line treatment for non-specific low back pain

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Low back pain (LBP) ranks as the number one disorder in terms of years lived with disability; estimated global one year incidences range from 22% to 65%.1 Back pain as a symptom, not attributable to spinal instability caused by trauma, infection, progressive deformity, or tumour, and not associated with radicular symptoms, is labelled non-specific LBP (see box). Many patients with non-specific LBP may have degenerative intervertebral disc and bony joint changes, including disc herniations and spinal stenosis on imaging, but these findings are not more common than in the general population, including people without LBP.2 Guidelines discourage surgery for non-specific back pain1; some recommend surgery only after two years of failed conservative treatments in carefully selected patients.3 However, despite these recommendations, the rate of back surgery is rising, with considerable geographical variation.4 The rates of spinal fusion, including use of surgical implants, for all degenerative disorders of the lumbar spine show an unexplained exponential increase,6 with a corresponding rise in serious perioperative complications, including stroke and cardiopulmonary events.7 These rises are unexpected, as the incidence of spinal diseases causing instability of vertebral elements has not risen, and nor has the incidence of surgery for herniated discs and stenosis.2 We propose that surgery should be avoided as first line treatment of non-specific LBP and that it is justified only in selected well informed patients after multidisciplinary conservative care has failed.

The evidence for change
For non-specific LBP, studies repeatedly show that surgery does not offer clinically relevant benefits over conservative interventions such as multidisciplinary treatment. For instance, in non-specific LBP with documented degenerative disc disease, a systematic review compared intradiscal electrothermal therapy with sham surgery.8 This included two randomised controlled trials (121 patients), which both showed no significant difference in outcomes, such as pain, disability, and quality of life. In a meta-analysis that included four higher quality randomised controlled trials (767 patients) comparing spinal fusion surgery with conservative interventions,
Advise use of rear

Don’t use aspirin for

Consider β blockers for

Cancer

Infection

Administer tranexamic

Compression stockings

Patients with heart failure

Children under 4 years

Facing child car seats for

Cardiovascular disease

Primary prevention of

Substantial bleeding

Patients at risk of

Spinal stenosis—Abnormal narrowing (stenosis) of the spinal canal causing compression of the spinal cord or nerve roots with associated neurological deficit including low back or radicular pain, numbness, paraesthesia, and muscle weakness

Non-specific LBP—Pain with possible tension, soreness, or stiffness in the lower back region, for which no specific cause can be identified. Several structures in the back, including the joints, discs, and connective tissues, may contribute to symptoms. Imaging findings of disc herniation and spinal stenosis may sometimes be incidental and are not more common than in people without LBP

Barriers to change

Evidence suggests that surgery may have a role in patients with sciatica from herniated lumbar discs or neurogenic claudication due to spinal stenosis. However, patients and physicians may wrongly extrapolate this to non-specific LBP, especially when pain is poorly controlled. The low threshold for performing magnetic resonance imaging for back pain may also result in the diagnosis of structural abnormalities of questionable clinical significance, triggering treatment algorithms and the quest for surgery. Placebo effects of surgery should also not be underestimated. In addition, the medical device industry expends great effort in promoting surgical procedures with implants, and complications are often underreported in the literature, especially where financial ties exist between authors and sponsors.

Reluctance to generate systematically collected evidence to support the rise in surgery for non-specific LBP might be explained by “surgical exceptionalism”—the view that the ethical or regulatory status of surgery is justified by its (questionably) unique nature. The view that if interventions do no good they will at least do no harm is a misunderstanding, especially given the potential discomfort for patients and possible risks of surgery.

Evidence based surgical practice is necessary to protect patients against unproved “treatments” and insufficiently tested devices, as well as to make rational decisions in times of scarcity.

Red flags prompting further diagnostic investigations in case of first episode of low back pain

<table>
<thead>
<tr>
<th>Clinical feature</th>
<th>Possible diagnosis</th>
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<tbody>
<tr>
<td>History of cancer</td>
<td>Cancer</td>
</tr>
<tr>
<td>Loss of bladder or bowel control</td>
<td>Cauda equina syndrome</td>
</tr>
<tr>
<td>Severe motor weakness (MRC scale ≤3) or progressive</td>
<td></td>
</tr>
<tr>
<td>motor weakness</td>
<td></td>
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<tr>
<td>Loss of sensation in buttocks (saddle anaesthesia)</td>
<td>Fracture</td>
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<tr>
<td>or progressive sensory deficit</td>
<td></td>
</tr>
<tr>
<td>Significant trauma</td>
<td></td>
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<tr>
<td>Chronic corticosteroid use, osteoporosis</td>
<td></td>
</tr>
<tr>
<td>Age &gt;70 years</td>
<td></td>
</tr>
<tr>
<td>Lumbar surgery in previous year</td>
<td>Infection</td>
</tr>
<tr>
<td>Urinary tract infection or bacterial sepsis</td>
<td></td>
</tr>
<tr>
<td>Immunosuppression</td>
<td></td>
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<tr>
<td>Injecting drug use</td>
<td></td>
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<tr>
<td>Unexplained fever</td>
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How should we change our practice?
In view of the above, spinal surgery should be avoided as first line treatment for non-specific LBP. It should instead be considered only as the last line of treatment for persistent and severe LBP if an adequate trial of multidisciplinary non-operative treatment, including a combined physical and psychological treatment programme, has failed and following adequate informed consent. This is in accordance with the NICE guidance, which found insufficient evidence to advocate surgery as first line treatment for non-specific LBP. Physicians should advise patients that, for non-specific LBP, evidence is lacking to show that surgery significantly improves pain, disability, and quality of life or is any better than physiotherapy, multidisciplinary non-operative care, or a careful “wait and see” approach.

Where non-operative measures are not readily available, healthcare organisations should ensure that these are a priority for implementation. Surgical societies and the medical community generally need to promote cultural change towards evidence based spinal surgery and create ample room for informed decision making by the patient during the consultation.

Magnetic resonance imaging can lead to misleading anatomical diagnoses and should not be performed for back pain. It should be considered only when referred is indicated for consideration of surgery. If pain due to sciatica or neurogenic claudication is significant or is impairing function or quality of life, imaging and subsequent surgical procedures should be considered. The indications are more urgent if red flags, such as a neurological deficit or a history of cancer, exist (table).

Any surgery for non-specific LBP should be done only under controlled study conditions. Surgical innovation outside a randomised controlled trial is not in itself unethical, but the patient should be fully informed about the lack of evidence for added value in terms of reduction in back pain and objective evaluation of clinically important outcomes should be ensured.

Contributors: WCP developed the concept of the article. WCHJ did the literature search and developed the first substantive draft. ALB discussed the ethical rationale of evidence based surgery and its implications. All three authors contributed to consecutive and final drafts and read and approved the final version. WCP is the guarantor.

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ANSWERS TO ENDCAMES, p 36
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ANATOMY QUIZ
Contrast enhanced axial computed tomography slice at the level of the transpyloric plane of Addison
A: Neck of the pancreas
B: Body of the gallbladder
C: Pylorus
D: Portal vein
E: Superior mesenteric artery
F: First lumbar vertebra

STATISTICAL QUESTION
Understanding P values
Statement a is true, whereas b and c are false.