Imaging Article

Radiographic Appearance of the Lumbar Spine After Lumbar Fusion

Christopher M. Viscomi, M.D., James P. Rathmell, M.D., and Robert D. Monsey, M.D.

Prior surgery on the vertebral column alters the anesthesiologist's approach to providing regional anesthesia for surgery. The medical history is often complex, the likelihood of successful neuraxial anesthesia diminished, and technical difficulties with needle placement increase. However, the anatomical changes after lumbar surgery are particular to the type of spinal surgery that has been performed. This article will present a series of radiographs of patients who have undergone various types of lumbar spinal fusion to illustrate how these surgeries differ from one another. An understanding of these anatomical changes can help the anesthesiologist who is considering neuraxial block in these patients.

Case Report

A 158-cm, 65-kg, 34-year-old G_3P_2 woman presented for obstetric anesthesiology consultation at 33 weeks gestation. This was a triplet gestation and she had experienced several episodes of premature labor. Cesarean delivery was planned.

This patient had undergone corrective surgery for scoliosis at age 14 using bilateral Harrington compression/distraction rods from T_4-T_{12}. At age 27, she underwent L_4-S_1 anterior-posterior fusion. She continued to experience intermittent back pain, but remained active and neurologically intact. She expressed the desire to be awake for her cesarean delivery.

Physical examination revealed mild residual scoliosis with a well-healed surgical incision from approximately T_3 to L_2 and from L_4 to mid sacrum. Radiographs taken after her second surgery were reviewed (Fig 1). A Harrington distraction rod is seen from L_1 extending cephalad. A compression hook is seen at T_{10}. There is marked rotation of the lumbar vertebrae with rightward deviation of the spinous processes, and a prominent fusion mass extending from L_5 to S_1. Despite the rotation, the interlaminar spaces at the $L_{1\text{-}2}$, $L_{2\text{-}3}$, $L_{3\text{-}4}$, and $L_{4\text{-}5}$ levels appear to be patent. The patient was advised that regional anesthesia was likely possible when it came time for her to deliver. Spinal anesthesia was recommended based on anticipated epidural scarring from Harrington rod placement as well as L_4-S_1 fusion.

At 34 weeks gestation, tocolysis was no longer effective. A 25-gauge Whitacre spinal needle was inserted at the $L_{3\text{-}4}$ interspace with approximately a 20° lateral orientation. Subarachnoid injectate was 11.25 mg of hyperbaric bupivacaine, 25 µg of fentanyl, and 0.2 mg of morphine. A T_3 sensory block was present in 8 minutes. The cesarean delivery was uncomplicated, resulting in the delivery of 3 viable male neonates. Recovery from spinal anesthesia was unremarkable.

Discussion

Many anesthesiologists view prior lumbar surgery as a contraindication to neuraxial anesthesia. However, the anatomical changes after different types of lumbar surgery depend on the type of surgery that was performed, and many surgeries have no impact at all on the posterior spinal elements.

Scoliosis is lateral curvature of the vertebral column. Scoliosis is more common in females. The most common form is idiopathic, but it may be secondary to neuromuscular disease (muscular dys-

From the Department of Anesthesiology, University of Utah Medical Center (C.M.V.), Salt Lake City, Utah; and the Departments of Anesthesiology (J.P.R.) and Orthopedic Surgery (R.D.M.), University of Vermont College of Medicine, Burlington, Vermont.
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Reprint requests: James P. Rathmell, M.D., Department of Anesthesiology, University of Vermont College of Medicine, 111 Colchester Ave, Burlington, VT 05401. E-mail: james.rathmell@vtmednet.org

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Fig 1. Antero-posterior radiograph of a patient with scoliosis who has undergone posterior spinal instrumentation with Harrington rods as well as L_4-S_1 fusion with autologous bone graft. The inferior extent of the Harrington rods with their laminar hooks can be seen at the top of the radiograph extending to the T_{10} level on the right and the L_1 level on the left. There is marked rotation of the lumbar spinous processes toward the right so that the left-sided facet joints can be clearly seen at the L_{1-2}, L_{2-3}, and L_{3-4} levels. The spinous processes are rotated toward the patient's right (small arrows). A fusion mass extends from the lateral process of L_5 to the sacral ala bilaterally (arrowheads). The right-sided interlaminar spaces appear to be widely patent at the L_{1-2}, L_{2-3}, L_{3-4}, and L_{4-5} levels (large arrows).

trophies, polio) or associated with specific syndromes (osteogenesis imperfecta, Marfan's syndrome). Severe scoliosis may interfere with childhood lung development and cause restrictive lung disease and right heart failure. This will generally occur only with curves of greater than 90°. Childhood screening and early corrective surgery have significantly lessened the prevalence of cardiopulmonary sequelae of scoliosis. Corrected thoracolumbar scoliosis is the most common major musculoskeletal disorder seen in pregnant women.[1]

The indications for surgery in idiopathic scoliosis include a progressive curve of greater than 40° to 50° or, in an adult, a painful curve of greater than 40° to 50°. Surgical management of scoliosis often involves the placement of a hook, screw, and rod construct to correct the spinal curvature and placement of bone graft to obtain fusion. The type of hardware used depends on the level and degree of the spinal abnormality. Harrington rods use small metal hooks placed under the bony lamina that then utilize distraction to stabilize and even correct the curvature (Fig 1). Harrington rods are now rarely used because more modern constructs with multiple hooks provide better correction of the curve with more initial stability and less chance of hardware complications such as hook displacement and less need for postoperative immobilization. Because of residual back pain and degenerative disease of the lower lumbar vertebrae, our patient had also undergone L_4-S_I fusion with placement of autologous bone graft (Fig 1). A characteristic sequence of vertebral body rotations and displacements occurs with scoliosis. The patient's radiograph (Fig 1) shows the typical vertebral body alignment. A review of the radiographs demonstrates a lumbar curve convex to the left with lateral deviation of the vertebral bodies from the midline. The spinous processes are rotated to the right. The interlaminar spaces at L_{1-2}, L_{2-3}, L_{3-4}, and L_{4-5} remain widely patent, thus guiding our approach to spinal placement.

Lumbar spinal fusion can be performed without instrumentation using autologous bone graft alone. This technique is used for short segment fusions (i.e., one of two levels) in patients without any deformity and with good healing potential (i.e., nonsmokers). Posterolateral placement of the graft proceeds to solid fusion more reliably than posterior graft placement because it is in a better vascularized environment. Biomechanically, grafts placed posterolaterally are closer to the center of rotation so the graft has a smaller magnitude of forces acting across it with less resulting motion. Figure 2 is a radiograph of an 18-year-old woman after L_{4-5} posterolateral fusion with autologous bone graft. The fusion mass can be seen extending between the transverse spinal process of L_4 and L_5. There is some cephalad extension of the fusion mass. In this case, no bone graft was placed between the laminae and

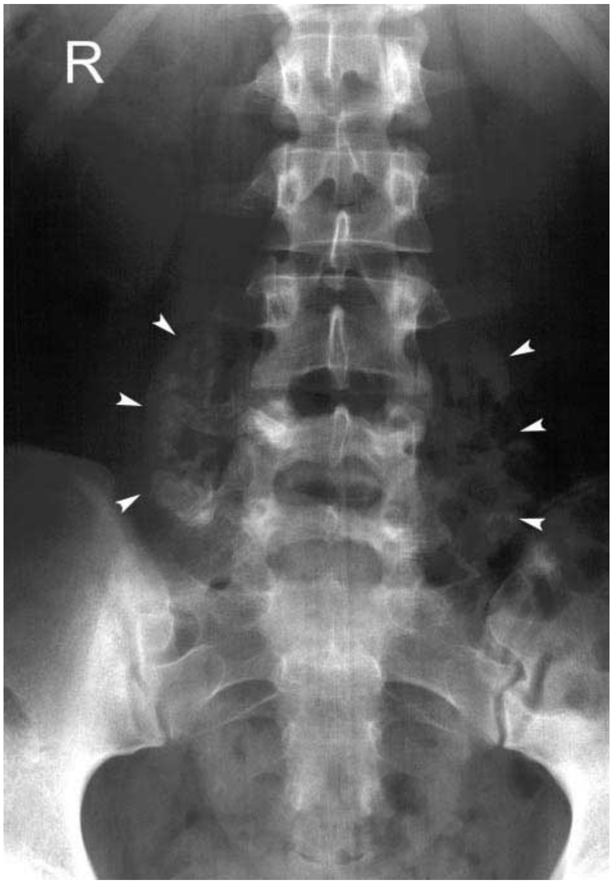

Fig 2. Antero-posterior radiograph of a patient who has undergone $L_{4\text{-}5}$ fusion with autologous bone graft. The fusion mass extends from the lateral process of L_4 to L_5 bilaterally (arrowheads). The anatomy of the lumbar interspaces is unaffected by the surgery.

the interlaminar spaces remain patent at all spinal levels.

Another approach to fusion is through placement of screws through the pedicles into the vertebral bodies. A metal rod is then inserted through the pedicle screws to keep the vertebral bodies immobile. Pedicle instrumentation is often used in situations where there is instability or deformity. The most common examples are fracture, a mobile spondylolisthesis (forward displacement of one vertebrae over another), or a scoliosis. The screw-rod construct immobilizes the instrumented vertebral bodies in the desired alignment. The decrease in motion between the vertebral bodies allows for better healing of the graft and leads to a higher incidence of solid fusion. Figure 3 illustrates this type of fusion in a man with elements of both scoliosis and spinal stenosis that were producing severe low back pain and bilateral leg pain. Pedicle screws are in place on the left at the L_3, L_5, and S_1 levels and on the right at the L_3, L_4, and S_1 levels. The posterior elements (spinous processes and laminae) have been surgically removed at both the L_4 and L_5 levels. In this case, the spinal instrumentation hardware is safely to the sides and there are no bony elements in the midline to impede placement of a needle for spinal anesthesia.

Newer techniques for spinal fusion can be accomplished from an anterior, retroperitoneal, or laparo-

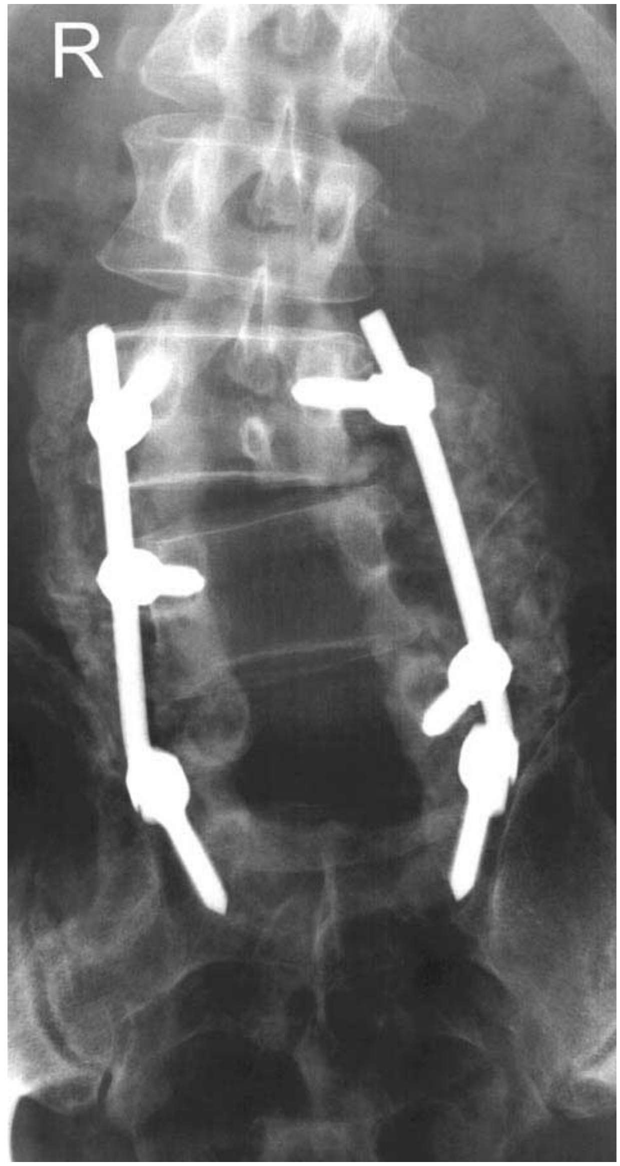

Fig 3. Antero-posterior radiograph of a patient who has undergone L_3-S_1 fusion with pedicle screw and posterior rod instrumentation and autologous bone graft and posterior decompression with removal of the spinous processes and lamina of L_4 and L_5. Surgical screws extend through the axis of the pedicles into the vertebral bodies. Pedicle screws are in place on the left at the L_3, L_5, and S_1 levels and on the right at the L_3, L_4, and S_1 levels. A fusion mass of autologous bone extends from the transverse process of L_3 to the sacral ala bilaterally.

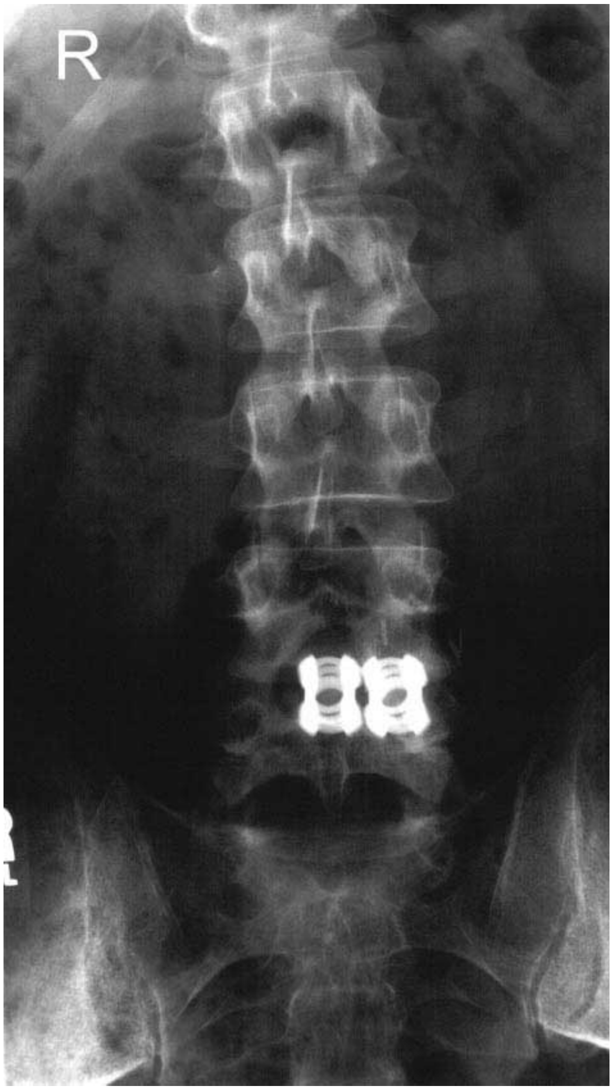

Fig 4. Antero-posterior radiograph of a patient who has undergone an $L_{4\text{-}5}$ interbody fusion from an anterior approach using titanium interbody cages and autologous bone graft. Two cylindrical implants can be seen side-by-side between the L_4 and L_5 vertebral bodies. The anatomy of the posterior lumbar interspaces is unaffected by the surgery.

scopic approach. Figures 4 and 5 are antero-posterior and lateral radiographs of a 50-year-old man following anterior spinal fusion. Two cylindrical titanium interbody cages have been inserted between the L_4 and L_5 vertebrae. Autologous bone graft was then placed into the cages and between the vertebral bodies anterior to the implants. This allows for better radiographic evaluation of the fusion consolidation. This technique is used to treat patients with low back pain secondary to degenerative disc disease who have failed extensive nonoperative management. This newer technique has several theoretical advantages: it allows restoration of intervertebral height and lordosis; avoids posterior surgery, thereby avoiding posterior muscle denervation and scarring; and the approach is fascial splitting, which should lead to less postoperative pain and faster recovery. In this case, the architecture of the posterior spinal elements is unaltered, and regional anesthesia can be performed without anticipating any difficulty.

Epidural analgesia is more difficult after corrective spinal surgery. Unsuccessful identification of the epidural space, multiple attempts before successful placement, unintentional dural puncture, failed block, and unusual block distributions can all occur.[2-6] These difficulties are likely secondary to

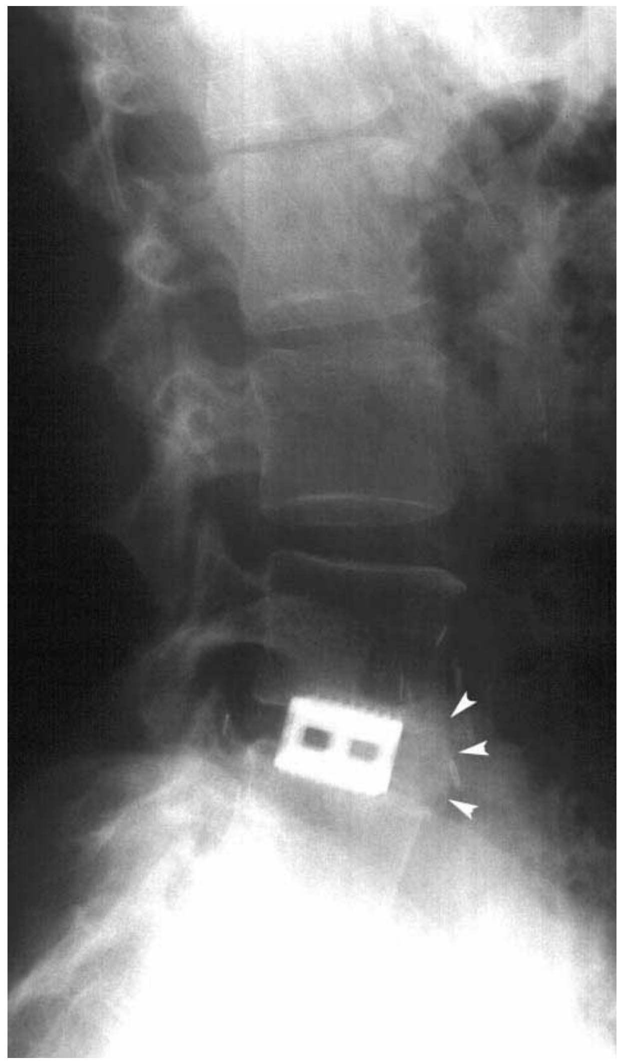

Fig 5. Lateral radiograph of a patient who has undergone $L_{4\text{-}5}$ interbody fusion from an anterior approach using titanium interbody cages and autologous bone graft. Two cylindrical implants can be seen side-by-side between the L_4 and L_5 vertebral bodies. A fusion mass of autologous bone graft extends between the anterior extent of the L_4 and L_5 vertebral bodies (arrowheads).

scarring or obliteration of the posterior epidural space from surgical dissection, anatomic interference from bone graft or surgical instrumentation, or vertebral rotation as discussed above. Scarring or obliteration of the epidural space is less problematic with spinal anesthesia. Review of plain radiographs can help in planning a successful approach to neuraxial block. When prior radiographs are unavailable or difficulties are encountered during block placement, portable fluoroscopy can be used to directly visualize the bony elements and any implanted hardware. Fluoroscopy units are readily available in most operating rooms and can be useful in facilitating neuraxial block in this patient population. A basic understanding of the anatomic changes after different types of lumbar spine surgery and radiographic examination using plain films or fluoroscopy can help the anesthesiologist to plan for effective neuraxial block in such patients.

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