CHAPTER 11

POSTERIOR LUMBAR APPROACH

David L. Kramer, M.D.
Robert E. Booth, Jr., M.D.
Todd J. Albert, M.D.
Richard A. Balderston, M.D.
The posterior midline approach to the lumbar spine is the most frequently used approach in surgery of the spine. It is an extensile approach that provides access to the posterior bony arch and pedicles of the spine, the underlying spinal cord, and the intervertebral disks. Accordingly, it is an approach well suited for posterior decompression of the spinal cord and exploration of exiting nerve roots in degenerative conditions of central and foraminal spinal stenosis. It allows unilateral or bilateral access to herniated disks. Intradural and extradural tumors may be exposed. When indicated, this approach may provide lateral exposure of the transverse processes for onlay in-situ bone grafting, as well as identification of the dorsal entry site of the cortical cylinder of the pedicle for biopsy of the vertebral body or for placement of bone screws used with instrumentation for posterior lumbar fusion.

Anatomy

The anatomy of the lumbar spine is well established. The lumbar vertebrae consist of relatively large vertebral bodies with blunt posterior arch structures. The superior articular facets are directed dorsomedially and lie anterolateral to the inferior articular facets of the more cephalad lumbar vertebra. As such, in degenerative conditions of the spine, it is primarily the superior articular facet that is responsible for lateral foraminal stenosis and the inferior articular facet that is responsible for central spinal stenosis (Figure 11-1).

- Figure 11-1. Inferior and superior articular process. The anterior margin of the superior articular process lies just posterior to the neuroforamen.
The pedicle is the cortical cylinder that connects the anterior vertebral body to its posterior bony arch. These cortical cylinders increase in diameter from L1 through L5. The axis of the pedicle creates an angle with the midline that also increases from approximately 7 degrees at L1 to 17 degrees at L5. The sagittal intervals between the pedicles, the intervertebral foramen, are elliptical conduits with vertical diameter 12 to 19 mm in height, through which pass the spinal nerve, artery, vein, and branches of the sinuvertebral nerve (Figure 11–2).

Several ligaments support and stabilize the bony contour of the lumbar spine (Figure 11–3). The supraspinous ligament is a continuous collection of collagen fibers running along the dorsal aspect of the spinous processes that add posterior column support and stabilize the cantilevered vertebral bodies anteriorly. The spinous processes are further stabilized to one another by the segmentally developed interspinous ligaments. The intertransverse ligament is also a segmental structure that is best developed in the lumbar spine and creates a fibrous sling between the transverse processes. The ligamentum flavum is a strong, elastic structure that originates on the ventral surface of a cephalad lamina and inserts on the superior lip of the next caudal lamina. Its resilient and elastic nature allows it to remain taut with lumbar extension and thereby avoid infolding with subsequent compression on the cord. The anterior longitudinal ligament consists of longitudinal bands of collagen fibers that run along the

![Figure 11-2](image_url). Anatomy of the intervertebral foramen in relation to the disk and pedicles. The two structures passing ventral to the spinal nerve are the sinuvertebral nerve and the artery. The other vessels are veins.
ventral surface of the spine from the skull to the sacrum. This broad anterior ligament is intimately related to the periosteum of the anterior vertebral bodies and loosely adherent to the intervening intervertebral disks. In contrast to this, the posterior longitudinal ligament is a thick but narrow band of fibrous tissue that runs along the posterior aspect of the vertebral bodies. Unlike the anterior longitudinal ligament, this ligament actually bowstrings over the vertebral bodies and has its strongest attachments at the level of the disk as it extends out laterally through the intervertebral foramen. This cruciform pattern may account for the observation that most disk herniations are lateral to this strong midline strap.

Figure 11-3. Ligaments of the lumbar spine.

Figure 11-4. Disk showing annulus fibrosis and nucleus pulposus.
The intervertebral disk comprises the outer annulus fibrosis, a series of concentric fibrous lamellae running oblique to the long axis, and the inner nucleus pulposus, composed primarily of water, type II collagen, and proteoglycan. The nucleus pulposus responds as a viscous fluid under pressure and as such acts to resist and redistribute axial compressive forces within the spine. In contrast, the annulus functions to resist tension from horizontal pressure that has been redirected by the nucleus in response to axial load (Figure 11–4). The annulus also resists torsional stress as well as stress created by the angular vertebral separation that permits lumbar flexion and extension.

Neural structures in the lumbar spine follow fairly consistent anatomic patterns. The conus medullaris is usually found between L1 and L2, below which the spinal cord continues as a collection of nerve roots collectively referred to as the cauda equina. The nerve roots of the cauda equina descend within the canal to exit beneath their respectively named pedicles (Figure 11–5). For example, the L4 nerve root descends posteriorly over the L3-4 disk before it turns laterally to exit beneath the L4 pedicle through the L4-5 foramen.

Blood supply to the lumbar vertebral elements and muscles is derived from a modified segmental system of vessels called the iliolumbar system. As opposed to the thoracic spine, where segmental blood flow comes off the aorta (which ends at L4), the segmental blood flow in the lumbar spine originates from branches of the fourth lumbar artery, the middle sacral artery, the internal iliac artery, and the iliolumbar artery (Figure 11–6). Dorsal
branches of this system reach the paraspinal muscles by ascending in the interval between the facet joints, just lateral to the pars interarticularis. It is this segmental vessel that is often encountered while dissecting within the soft tissue lateral to the pars (Figure 11–7).

The muscles of the lumbar spine may be divided into three layers: superficial, middle, and deep (Figure 11–8). The superficial layer consists primarily of muscles related to the shoulder girdle: the latissimus dorsi, trapezius, and serratus posterior. As such, these muscles are innervated by peripheral nerves taking their origin within the brachial plexus. The intermediate layer consists of long, longitudinal muscle masses extending over several motion segments. Taken together, these are referred to as the erector spinae (from lateral to medial: iliocostalis, longissimus, spinalis). The deep layer is the only layer composed of true spinal muscles, in that they are innervated and have origins and insertions at each spinal
level. The muscles that make up this layer are the multifidi, rotatores, levatores, and intertransversarii.

**Surgical Approach**

Proper positioning of the patient is the crucial first step in minimizing total blood loss during the posterior lumbar approach. By ensuring that the abdomen is allowed to hang free, intra-abdominal pressure is kept at a minimum, thereby reducing spinal venous pressure and decreasing subsequent bleeding. Several frames exist that allow such decompression of the abdomen and free excursion of the chest (Figure 11–9). The criticism of these frames is that they tend to increase lumbar lordosis, making laminotomy and lateral recess decompression somewhat more difficult. This position of relative hyperextension, however, reproduces the axial compression of the neural elements. If the spine is effectively decompressed in this extended position, relief of radicular symptoms may be expected when the patient is erect. When kneeling frames are used, care should be taken to thoroughly pad all bony prominences (knees, anterior tibiae, elbows) and abduction of the arms should not exceed 90 degrees to the trunk axis.

The length of the incision is determined by palpation of the spinous processes of the appropriate levels. The skin incision is made in the midline directly over these spinous
processes after infiltrating the skin with 1:100,000 epinephrine solution (usually with 0.25% Marcaine). Dissection is carried down through the subcutaneous adipose tissue, either sharply or with electrocautery, to the level of the lumbodorsal fascia. This thick fascial layer, clearly seen in the anatomic specimen (Figure 11–10), is composed of the fascial extension of the latissimus dorsi, the quadratus lumborum, and the trapezius and envelops the underlying erector spinae muscles. The deep fibers of the lumbodorsal fascia coalesce with the periosteum of the spinous processes and laminae medially and with the fascia of the psoas anteriorly. By performing a subperiosteal dissection along the spinous processes, one can, for the most part, preserve this muscle envelope and avoid violation of the intramuscular vessels. The tip of the spinous processes has a bulbous shape. Accordingly, dissection with the elevator or cautery must be directed initially dorsally to go under the edge and thus avoid dissecting into the paraspinal musculature. This is the first obstacle to be addressed in the posterior approach, because meticulous hemostasis is required to prevent the slow, persistent bleeding, pooling within the depths of the wound, that may plague the surgeon for the remainder of the surgical procedure. Avoidance of straying into the muscles may be facilitated by gentle lateral retraction of the erector spinae muscles with a Cobb elevator, thereby delineating under tension the origin of the deeper segmental muscles (i.e., multifidi) as they originate off the interspinous ligaments (Figure 11–11). This subperiosteal dissection is carried in a distal to proximal direction as the paraspinal muscles originate obliquely on the midline interspinous ligament. Instruments passed from caudal to cephalad will stay in the subperiosteal plane, thus avoiding further muscle bleeding.
The second obstacle encountered during the posterior approach is the dissection carried out lateral to the facet joints. As mentioned, this lateral extension is usually required only during the approach for fusion using posterolateral bone graft or pedicle instrumentation. Once the subperiosteal dissection has been carried down to the level of the lamina, care must be taken to avoid inadvertent subperiosteal dissection into the facet joint. This may be difficult in spondylarthritic spines where facet osteophytes cause medial overhang of the
Figure 11-10. The lumbosacral fascia envelops the underlying erector spinae muscles. The deep fibers of the fascia coalesce with the periosteum of the spinous processes and lamina medially and with the fascia of the psoas anteriorly.

Figure 11-11. Subperiosteal dissection of paraspinal muscles off the spinous process and laminae.
inferior articular process. Once the medial margin of the facet joint is encountered, self-retaining retractors may be placed to enlarge the operative field and to compress the intramuscular vasculature to reduce hemorrhage. Delineation of the pars interarticularis is an extremely helpful maneuver as it defines the lateralmost margin of the canal between the pedicles. Subperiosteal removal of soft tissue overlying the pars is facilitated by carefully cutting down to the bone with a Cobb elevator perpendicular to the axis of the pars and then gently rotating the elevator laterally against the bone, sweeping the soft tissue lateral to the pars. Electrocautery can be used with this maneuver to facilitate the removal of the soft tissue. In cases of spondylolisthesis or spondylolysis, one must exercise extreme caution to avoid penetration through a fibrous or dysplastic pars defect. Additional brisk bleeding is often encountered immediately lateral to the pars, between the facet joints. This arises from inadvertent and planned interruption of the segmental facetal artery previously described. These vessels may be safely controlled with electrocautery as the neural elements pass deep to the transverse processes and intervening intertransverse ligament. Dissection of the paraspinous muscles off the facet joints is facilitated by gently retracting the muscle mass up and over the intact facet joint capsule. By applying lateral tension to the muscle, muscle fiber origins arising from the joint capsule are more clearly delineated and may be dissected off under direct visualization, thereby preserving the facet joint capsule (Figure 11-12). Preservation of the intact facet joint is necessary if the surgeon wishes to preserve stability of the spine while avoiding fusion of the motion segment.

The last obstacle to be overcome during this approach is the exposure of the transverse processes. These may be palpated lateral and just caudal to each facet joint. Each facet joint is composed of the superior articular process of the caudal vertebra and the inferior articular process of the cephalad vertebra. As described earlier, the superior articular process of the caudal vertebra lies anterolateral to the inferior articular process of the cephalad vertebra. The transverse process may be identified by following the base of the superior articular process out laterally. The pedicle may also be located directly anterior to the base of the superior articular process. One can easily see how the anatomy of the facet joint serves as an important guide for understanding the three-dimensional anatomy of the spine (Figure 11-13). A Cobb elevator may then be gently applied to the dorsomedial aspect of the transverse process, and a gentle lateral sweeping motion will facilitate definition of the upper and lower borders of the process. Electrocautery may then be used to subperiosteally dissect the segmentally arising muscles (intertransversarii, rotatores, levatores) off the bony process. Care must be taken to avoid excessive downward force against the process because it is easily fractured. All attempts must be made to preserve the intertransverse ligament, because it serves to define the safe boundary anterior to which injury to the nerve roots, vascular structures, and retroperitoneal space may take place. This ligament also serves as a fibrous sling on which to place bone graft for an intertransverse process fusion (Figure 11-14). Once sufficient lateral exposure has been obtained, the lateral gutters may be tamponaded with thrombin-moistened sponges and attention may be turned to carrying out the procedure at hand.

In the case of decompressive laminectomy, attention is directed to the midline interval between the ligamentum flavum and the superior edge of the lamina defining the caudal extent of the decompression. This is most readily accomplished using a medium-sized (2 mm) curved curet with a gentle sweeping motion against the superior laminar edge (Figure 11-15). The curet must be supported with two hands to avoid inadvertent penetration of the ligamentum, which, owing to its segmental origin, may be quite thin where it meets (but does not fuse) with its homologue in the midline. Once the caudal insertion of the ligamentum has been taken down and entry into the canal has been accomplished, Kerrison rongeurs may be placed carefully within the canal, taking care to maintain contact of the boot of the instrument with the undersurface of the lamina. In the event that any resistance is encountered with the Kerrison rongeur, a Penfield dissector may be used to
**Figure 11-12.** A and B. The paraspinal musculature is dissected off the facet capsules under tension, thereby exposing the transverse processes laterally.
gently release any sublaminar adhesions. In this fashion, a central trough may be created across the levels to be excised in a caudad to cephalad direction (Figure 11–16). This trough may then be widened using Kerrison rongeurs angled caudad and laterally toward the lateral recess. Care must always be taken to keep the angle of the Kerrison rongeur parallel with the dura to avoid inadvertent trapping of the dura within the teeth of the instrument. By proceeding in this fashion, the lateral recesses may be decompressed of facetial osteophytes and hypertrophy of the ligamentum as it extends out laterally toward the foramen.

If fusion with pedicle instrumentation is desired, one must first identify the axis of the pedicle. The dorsal entry site to the cortical cylinder of the pedicle is identified at a point formed by the intersection of a line bisecting the transverse process in the coronal plane with a perpendicular line just lateral to the base of the superior articular process in the parasagittal plane (Figure 11–17). Entry to the pedicle is made with a bur or awl. As described, the angle created by the axis of the pedicle relative to the midline increases as one proceeds from L1 to L5.

Unilateral laminotomy for diskectomy is carried out with an approach similar to that used for lumbar laminectomy, although the dissection is carried out only on one side of the interspinous ligament. With this approach, one can limit the size of the initial skin incision. Dissection proceeds to the level of the lumbodorsal fascia. At this point, sharp dissection through this fascial layer proceeds between the spinous processes above and below the affected level only on the side of the pathology. By subperiosteally sweeping the paraspinal musculature off of the spinous processes and intervening interspinous ligament with a Cobb elevator, one can gain access to the laminae overlaying the disk herniation. The paraspinal
musculature is held lateral to the facet joint with a Taylor retractor. As in the case of decompression for spinal stenosis, the interval between the superior edge of the caudal lamina and the ligamentum flavum is exploited with a small curved curet. Kerrison rongeurs are then used to create a laminotomy overlying the disk herniation by resecting a portion of the superior edge of the caudal lamina and the inferior edge of the cephalad lamina (Figure 11–18). One must keep in mind that the L5-S1 disk is at the level of the interlaminar space; yet as one progresses in a cephalad direction, the disk space proportionately is in a more cephalad position than the interlaminar space. Exposure of the L2-L3 disk space therefore requires more removal of the L2 lamina because the disk is in a more cephalad position compared with the interlaminar space. Removal of some bone from the medial aspect of the pars interarticularis may be necessary to gain enough lateral exposure to the underlying disk, although at least 8 mm of the pars should be left intact to preserve stability. Once again, preserving the facet capsule is paramount to preserving stability of the motion segment. Once the laminotomy is created, the dura and affected nerve root may be identified and gently retracted toward the midline, exposing the underlying disk herniation (Figure 11–19).

Closure of the posterior lumbar approach involves reapproximating the paraspinal musculature with interrupted absorbable sutures in an attempt to close the potential space created
by the lateral dissection. The lumbodorsal fascia is then reapproximated to itself as the strength layer in the closure, using interrupted or running absorbable sutures. The subcutaneous layers and skin are then closed in a standard fashion of the surgeon’s choosing.

**Complications**

Complications encountered with this approach include (1) identification of the wrong level, (2) injury to neural elements, (3) excessive bleeding, and (4) destabilizing the motion segment. Prevention is the key to avoiding each of these complications.

Identification of the appropriate level can be ensured by several means. The most important step is to carefully evaluate the preoperative films. One should determine if there are any “sacralized” or “lumbarized” vertebrae. Significant anterolisthesis or retrolisthesis must also be identified. Evaluation of spinal dysraphism such as spina bifida occulta is critical to avoid penetration of the canal and injury to the neural elements. The sacrum is usually easily identifiable. No motion between spinous processes is detected when one sacral spinous process is moved with a Kocher clamp. Tapping on a sacral lamina also tends to
During the laminectomy, a central trough is created in a caudad to cephalad direction (A). The trough is then widened (B) with the Kerrison rongeur toward the lateral recesses.
produce a relatively dull sound when compared with nonfused lumbar segments. An intraoperative lateral radiograph should always be obtained with a Kocher clamp on the cephalad portion of the spinous process at the level of the pathologic process. A Kocher clamp in this position tends to be directly posterior to the pedicle at that level and may allow more clear identification of the marked level.

Neural elements, especially nerve roots, must be identified individually and protected. The more lateral the dissection, the easier it is to identify the nerve root and retract it so that the disk may be seen. Realization that the dura may be closely applied, and at times adherent to, the undersurface of the ligamentum flavum inspires the surgeon to exercise extreme caution and meticulous handling of this soft tissue plane.

Excessive bleeding may be avoided by taking several preventive measures throughout the procedure. Staying strictly subperiosteal during the initial approach through the paraspinal muscles should ensure a relatively dry exposure of the posterior bony elements. Identifying the pars interarticularis early in the dissection followed by cauterization of the segmental facet artery just lateral to the pars will assist in maintaining a dry field during exposure of the transverse processes. A branch of the posterior primary ramus of the lumbar nerve root tends to run with the segmental vessel as it passes adjacent to the facet joint and pars interarticularis. As it supplies the paraspinal musculature in a segmental fashion, loss of some of these nerve branches tends not to significantly denervate the muscle. Care must be taken to avoid penetration of the coronal plane between the transverse processes, because significant bleeding may arise in the retroperitoneal space. Excessive bleeding may also be encountered during blunt dissection through the epidural venous plexus en route to the disk.
This bleeding may be lessened with proper positioning on a laminectomy frame and with the use of a spinal anesthetic. If encountered, it may be controlled with Gelfoam and thrombin-soaked cottonoid patties. Bipolar Malis electrocautery may also be used with caution to coagulate identifiable venous bleeding vessels. Lastly, penetration of the anterior annulus fibrosus with an open pituitary rongeur during overzealous resection of the intervertebral disk may also lead to devastating consequences, such as injury to the adjacent iliac vessels.

Unless a fusion is part of the preoperative plan, no posterior surgical approach to the lumbar spine is likely to improve stability. Accordingly, the surgeon must rely on technique to preserve stabilizing structures wherever possible. As emphasized, facet joint capsules must be identified and protected. If a unilateral approach to the spine is used, the supraspinous and interspinous ligaments should also be preserved. The pars interarticularis imparts bony stability between the facet joints. Excessive resection of the pars during laminectomy (i.e., less than 5 to 8 mm of pars remaining) may result in subsequent fracture, predisposing the motion segment to a state of instability. If significant resection of the pars is required to achieve a complete decompression of the nerve root, one should incorporate a fusion across the involved motion segment.
Conclusion

The three-dimensional anatomy of the lumbar spine must be clearly understood to be able to locate anterior structures when looking at the posterior aspect of the spine. The key to the posterior topographic anatomy of the spine is the facet joint. By identifying this structure, one can identify the location of the transverse process as well as the underlying pedicle. The key to the anatomy within the canal is the pedicle. Identification of the pedicle orients the surgeon to the level of the disk and the position of the exiting nerve root through its foramen. Respect for those soft tissue and bony elements that contribute to spinal stability is necessary if one is to successfully approach the posterior aspect of the spine without doing harm to the patient.

BIBLIOGRAPHY