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CHAPTER 10.3

Spine Surgery

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Minimally Invasive Posterior Lumbar Discectomy (Microdiscectomy)

Surgical Considerations

Description: Since the mid-1990s, a number of techniques have been developed to allow the decompression of lumbar roots (removal of disc material) with as little trauma to the nerves and surrounding tissues as possible. In most instances, little or no bone is removed and, therefore, this is not technically a laminectomy or laminotomy. These minimally invasive procedures typically are carried out in healthy young or middle-aged adults with sciatica and are not done for more involved pathology, such as deformity, tumor, or infection. **Transpedicular fixation** and **short-segment fusions** may be attempted using modifications of these techniques.

Microdiscectomy approach: This can be done under GA, regional (epidural or spinal), or local anesthesia. The patient is placed in a prone or kneeling position and the posterior landmarks are palpated to identify the approximate level (e.g., L4/5); then the overlying skin is infiltrated with local anesthetic. A spinal needle is placed to the level of the lamina and an x-ray or fluoroscopic image is taken to confirm the level. A 1" incision is made over the proposed interspace and, using either traditional or specialized retractors, the soft tissue is displaced to expose the ligamentum flavum. With the use of an operating microscope, the ligamentum flavum is removed, the nerve retracted, and the extruded disc excised. For a single level, this should take between 30–90 min, depending on the size of the patient and whether there is any scarring or adhesions from previous surgery.

Variant approach: Percutaneous discectomy through a posterolateral approach is usually reserved for “contained discs”—protrusions into, but not through, the outer annulus of the disc. These are usually done under MAC with local anesthetic. The percutaneous instruments may be positioned using fluoroscopic guidance with or without a fiber optic light source and camera/monitor setup. The disc space is entered posterolaterally. The surgeon usually avoids anesthetizing the area around the nerve root so that the patient can alert the team if the root is struck by an instrument (quite painful). After the disc space is entered, fluoroscopic or camera images are used to guide the surgeon in the removal of herniated disc. The disc material can be removed with specialized grabbers or automatic power-driven shavers.

Usual preop diagnosis: Chronic back pain 2° herniated lumbar disc; lumbar radiculopathy

Summary of Procedures

	Microdiscectomy	Percutaneous Discectomy
Position	Prone or kneeling, with bolster or frame support. The abdomen must hang free to decompress the epidural veins.	Prone or lateral decubitus
Incision	Posterior midline or slightly off midline, at the appropriate vertebral level	About 8–12 cm lateral to the midline at the appropriate vertebral level
Special instrumentation	Microscope; light source; specialized retraction and dissection instruments for working in a small, deep incision	Percutaneous instruments, including trocars, sounds, and arthroscopic-type grabbers and shavers; fluoroscopy; and, sometimes, camera/monitor and fiber optic light setup
Unique considerations	Often outpatient procedure. Need to make room for microscope at head of	Patient must be alert enough to respond

Antibiotics	bed.	to pain if nerve roots are encountered.
Surgical time	Cefazolin 1 g iv	
Closing considerations	0.5–1.5 h	1–2 h
EBL	Minimal suturing	Usually no closure (Band-aids)
	25–100 mL	Minimal
Postop care	PACU. Mobilization as soon as tolerated. Usually discharged within 24 h.	PACU → home. Mobilization as tolerated.
Mortality	Very rare	
Morbidity	Nerve injury Dural laceration Infection	Failure to decompress the nerve adequately —
Pain score	4	2

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Patient Population Characteristics

Age range	16–60 yr
Male:Female	3:2
Incidence	Common
Etiology	Degenerative; trauma (rare)

■ Anesthetic Considerations

▲ Preoperative

Young and middle-aged adults are usually healthy; the elderly may have cardiovascular and/or pulmonary disease.

Since these patients may have chronic back pain with radiculopathy, they may not be suitable candidates for regional anesthetic techniques. Postop exacerbation of symptoms may be incorrectly ascribed to the anesthetic technique. A careful motor and sensory evaluation of the lower extremities should be documented. Patients commonly taking centrally acting analgesics (e.g., Ultram); narcotics (e.g., Darvon, Darvocet, OxyContin, Percocet, Vicodin); NSAIDs (e.g., Feldene, Naprosyn, Relafen, Voltaren); or COX-2 inhibitors (Celebrex) often require higher doses of sedative-hypnotics and analgesics in the periop period.

Patients should stop taking aspirin or NSAIDs at least 2 wk before surgery. In addition, an INR or PT and PTT should be checked preop.

Tests: Hct; Plt; INR

Other tests as indicated from H&P.

Standard premedication (see [p. B-1](#)).

Musculoskeletal

Hematologic

Laboratory

Premedication

◆ Intraoperative

Anesthetic technique: Microdiscectomies are commonly done under GA; however, local or regional anesthetic techniques are suitable in selected patients. Care must be taken to avoid encroaching on the surgical site. Percutaneous discectomies typically require only MAC with sedation. These patients must be awake in order to alert the surgeon to inadvertent nerve root contact. In some centers, regional anesthesia (spinal or epidural) is the anesthetic of choice.



General Anesthesia:

Induction

Standard induction (see [p. B-2](#)). Consider using wire-reinforced ETT to prevent kinking, with patient in prone position.

Maintenance

Standard maintenance (see [p. B-2](#)). Usually 1–2 h operation.

Emergence

After exposure, further relaxant use is unnecessary.

MAC

No special considerations

See [p. B-3–B-4](#).

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Regional anesthesia:

Spinal

Patient in sitting, lateral decubitus, or prone position for placement of subarachnoid block. Doses of local anesthetics should be adequate to provide a high lumbar level of sensory anesthesia (e.g., bupivacaine 6–10 mg with fentanyl 10 mcg). Patient in sitting or lateral decubitus position for placement of epidural catheter. A test dose (e.g., 3 mL of 1.5% lidocaine with 1:200,000 epinephrine [5 mcg/mL]) is administered and the patient is observed for development of subarachnoid block or Sx of an intravascular injection. Titrate lidocaine 2% with epinephrine (3–5 mL at a time) until desired surgical level is obtained.

Epidural

Blood not likely to be required.

Blood and fluid requirements IV: 18–20 ga × 1
NS/LR @ 5 mL/kg/h

Monitoring

Standard monitors (see [p. B-1](#)).

Positioning and pad pressure points.

Prone position: Wilson frame or bolsters to support shoulders/hips and optimize ventilation.

Knee-chest position: Andrews table.

Place head in cushioned holder with cutout for eyes, nose, chin (e.g., Andrews Gentle-Rest pillow). Make certain nose and chin do not touch table. Pad elbows, knees, other pressure points.

Postoperative

Complications

Urinary retention in the older patient

Rx: Consider catheterization.

Transient numbness/paresthesias, weakness

Due to nerve-root irritation from operation.
Rx with analgesics and/or muscle relaxants (e.g., Flexeril, Robaxin, Soma).

PCA ([p. C-3](#))

Ketorolac 30 mg iv

PO analgesics may be suitable:

Epidural analgesia ([p. C-2](#))

acetaminophen and codeine (Tylenol #3 1–2 tab q 4–6 h) or oxycodone and acetaminophen (Percocet 1 tab q 6 h)

Pain management

As indicated by patient status

Patient usually discharged from hospital within 24–48 h.

Tests

Suggested Readings



1. Bookwalter J III, Busch M, Nicely D: Ambulatory surgery is safe and effective in radicular disc disease. *Spine* 1994; 19: 526–30.
2. Carragee E, Helms E, O'Sullivan G: Are post-operative activity restrictions necessary after posterior lumbar discectomy? A prospective study of outcomes in 50 consecutive cases. *Spine* 1996; 21:1893–7.
3. Javedan S, Sonntag VK: Lumbar disc herniation: microsurgical approach. *Neurosurgery* 2003; 52(1):160–4.
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Anterior Spinal Reconstruction and Fusion—Thoracic and Thoracolumbar Spine

Surgical Considerations

Description: Traditionally, most spinal procedures have been approached posteriorly. The advent of surgical treatment for vertebral TB and postpolio spinal deformities during the 1960s saw the development of surgical approaches to the anterior spine. These procedures initially were reserved for patients with significant deformities, especially kyphosis. More recently, the treatment of traumatic, neoplastic, and degenerative conditions have been included in the anterior approach. Regardless of the condition under treatment, the approach is similar for a given level. There are several more or less distinct types of surgical exposures, depending on the level.

Cervicothoracic approach: Most cephalad and difficult is the approach to the upper thoracic spine (T1-T3). This generally includes a modified anterior cervical exposure with a caudal extension, including a resection of the clavicle, part of the manubrium, and sometimes the rib at the thoracic outlet. Dangers in this exposure are to the great vessels at the thoracic outlet, trachea (rare) and esophagus (more common), lung parenchyma, sympathetic ganglia, lymphatic duct (on the left), and brachial plexus. Once the spine is exposed and the discs and/or vertebrae are removed, the spinal cord is at risk. This procedure occasionally involves entering the thoracic cavity, in which case it is usually done intrapleurally—that is, through the parietal pleura. The lung needs to be collapsed at least partially. Spinal cord monitoring is usually performed; wake-up tests are not. Manipulation of the carotid artery and aortic arch may cause wide HR and BP fluctuations.

Transthoracic approach: Further down the spine, the levels from T5-T10 are more easily reached via a transthoracic approach [Fig. 10.3-1](#). This involves a typical thoracotomy with the resection of a rib. The level of the rib resection is usually 1–2 levels above the highest vertebral level being approached. The great vessels and lung parenchyma are at risk, as is the thoracic duct (on the left). The patient is in the lateral decubitus position and the mediastinum and heart usually fall to the opposite side, out of harm's way. Risk to the spinal cord depends on the difficulty and extent of the vertebral disease and the reconstruction. Spinal cord monitoring usually is performed intraop. The need for (Print pagebreak 966) the lung to be deflated varies with the extent of the exposure. In centers where this procedure is frequently performed and the surgeons are accustomed to the respiratory motion during operation, DLTs are not routinely used. Because there is no (intended) violation of the lung parenchyma, air leaks and parenchymal repairs are not common.

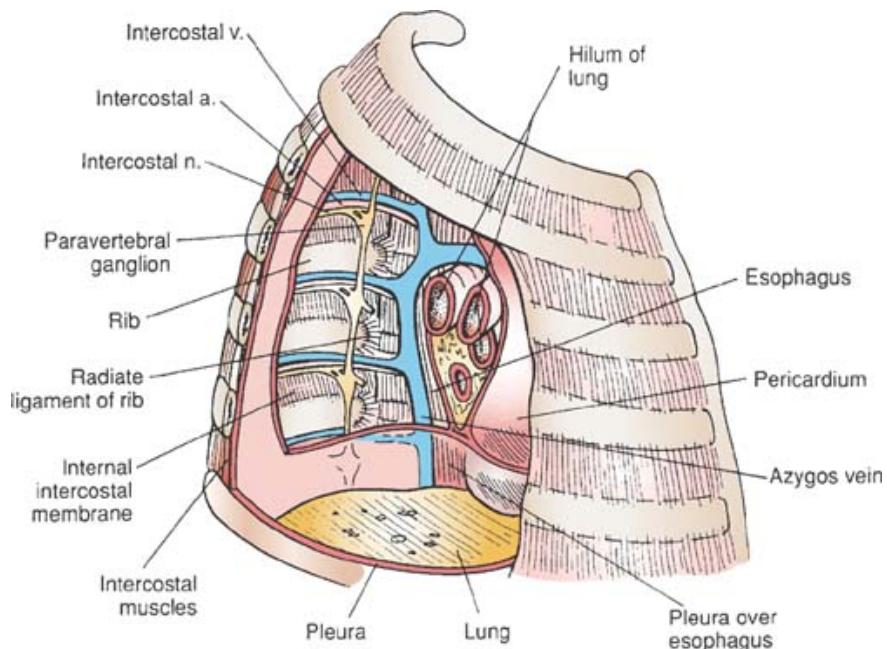


Figure 10.3-1. 1. Surgical anatomy of the transthoracic approach. (Reproduced with permission from Hoppenfeld S, deBoer P: *Surgical Exposures in Orthopaedics*. JB Lippincott, Philadelphia: 1984.)

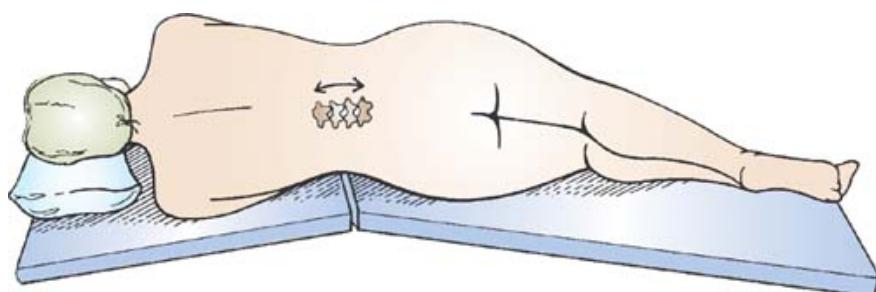


Figure 10.3-2. 2. Patient position for transdiaphragmatic or retroperitoneal approach. (Reproduced with permission from Hoppenfeld S, deBoer P: *Surgical Exposures in Orthopaedics*. JB Lippincott, Philadelphia: 1984.)

Transdiaphragmatic approach: When the exposure must transverse the diaphragm, a combined retroperitoneal and transthoracic approach is used. This requires the diaphragm to be sectioned circumferentially from the chest wall and spine. If only the very low segments of the thoracic spine (T10-T12) are exposed, the required deflation of the involved lung is minimal. The risks are the same as those encountered with the transthoracic or retroperitoneal approaches alone. Regardless of the level of exposure, the operating table may be used during the procedure to manipulate the spine for better exposure and to “lock in” implants, bone grafts, etc. Usually, the area of the spine to be exposed is centered above the “breaking” joint and kidney rests of the table (Fig. 10.3-2). After the initial exposure, the table is angled in the center with the head and legs pointing down and kidney rests elevated to “open up” the section of spine facing the surgeon. After removal of the disk, abscess, or tumor, a reconstruction—using bone graft, metal implants, bone cement, or a combination of these—is performed. The operating table is straightened and, with the spine in neutral alignment, the stability of the reconstruction is tested. This maneuver may need to be repeated several times.

The **morbidity** of these procedures depends primarily on the nature of the underlying disease. Obviously, bleeding and visceral injury are more likely when debriding a grapefruit-sized Potts abscess with several destroyed vertebrae than in removing a degenerated lumbar disk for fusion.

In some instances, the anterior procedure may be followed with a posterior fusion, either immediately or after 5–7 d of convalescence. If done immediately after, the patient needs to be placed in the prone position and the second procedure needs to be done through a midline exposure. Sometimes anterior and posterior surgeries are performed simultaneously by two surgical teams. The most common reason for a staged anterior/posterior procedure (in the United States) is scoliosis; however, fractures at the thoracolumbar junction, after anterior decompression and reconstruction, are often instrumented and fused posteriorly.

Usual preop diagnosis: Fractures (usually at thoracic lumbar junction); idiopathic scoliosis; primary neoplasm or metastatic disease to the spine; pyogenic or TB osteomyelitis of the spine; Scheuermann's kyphosis

Summary of Procedures

	Cervicothoracic Approach	Transthoracic Approach	Transdiaphragmatic Approach
Position	Supine; towel roll placed between shoulder blades, head slightly extended and turned away from operated side	Lateral decubitus (Fig. 10.3-2); intended segments over the table break and kidney rests; axillary roll	
Incision	Inverted "L" longitudinally along manubrium to sternal notch, then transversely above clavicle	Along a rib, two levels above the highest segment to be exposed	
Special instrumentation	Instrumentation rarely used. Strut grafts—using rib, fibula, clavicle or cement—may be used to replace excised vertebrae. ± DLT	For thoracolumbar scoliosis, a Zielke-type rod and screws may be used; more rigid instrumentation sometimes used in fractures. ± DLT	(More common to use instrumentation at the affected level than above.)
Unique considerations	Aortic arch and carotid manipulation may cause BP/HR changes. Postop respiratory distress well described.	During spinal reconstruction, manipulation of operating table may be essential to "lock in" graft or implant (see above).	
Antibiotics	Cefazolin 1 g iv (+ gentamicin 80 mg iv, if indwelling bladder catheter)		
Surgical time	2–6 h		
Closing considerations	Patient usually transferred to bed prior to emergence; sudden jerking motions may dislodge graft or implant.		
EBL	200–5000 mL. Blood loss is extremely variable; when bleeding occurs, it may be torrential from the aorta, vena cava, or iliac vessels and branches. In nontumor or infection cases, 200–400 mL is usual.		
Postop care	Chest drain; NG suction usually needed; short period of ICU observation is usual.		
Mortality	< 0.1%, except in cases of malignancy or sepsis		
Morbidity	For elective degenerative cases: 5–10% overall DVT: 6% Neurological: 3% Infection: 1% Sexual dysfunction For sepsis or tumor: 50–80% (overall) Cardiorespiratory failure Sepsis		
Pain score	7–8 (if patient sensate at level of surgery)	7–8 (if patient sensate at level of surgery)	7–8 (if patient sensate at level of surgery)



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Patient Population Characteristics

Age range	12–30 yr (scoliosis surgery); > 40 (tumor and infection surgery); 15–35 yr (fractures)
Male:Female	1:1, except more scoliosis surgery in females (1:4) and more fractures in males
Incidence	20,000/yr
Etiology	Scoliosis: idiopathic (50%), neuromuscular (15%), congenital (5%); trauma (20%); infections, tumors (10%) Pulmonary HTN and impaired pulmonary function; neuromuscular scoliosis (poliomyelitis, CP, muscular dystrophy, Friedreich's ataxia); aspiration; cardiomyopathy
Associated conditions	

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Anesthetic Considerations

See [Anesthetic Considerations for Spinal Reconstruction and Fusion, p. 971](#).

Suggested Readings

1. Butler J, Schafer MF: Anterior approach to scoliosis. In *Chapman's Orthopaedic Surgery*, 3rd edition. Chapman MW, ed. Lippincott Williams & Wilkins, Philadelphia: 2001, 4011–30.
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4. McLain RF, Benson DR: Operative treatment of thoracic and thoracolumbar fractures. In *Chapman's Orthopaedic Surgery*, 3rd edition. Chapman MW, ed. Lippincott Williams & Wilkins, Philadelphia: 2001, 3725–45.
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6. Taft E, Francis R: Evaluation and management of scoliosis. *J Pediatr Health Care* 2003; 17(1):42–4.
7. Tay BK, Deckey J, Hu SS: Spinal infections. *J Am Acad Orthop Surg* 2002; 10(3):188–97.

Anterior Spinal Reconstruction and Fusion—Lumbosacral Spine

Surgical Considerations

Description: The same general considerations apply here as in thoracolumbar reconstruction segments. The thoracic cavity is not entered, nor is the diaphragm sectioned. Careful preop assessment is needed, as these patients may have a wide range of coexisting diseases. The same operative procedure is performed for removal of a degenerative disk in a healthy patient as is carried out to decompress the cauda equina in a debilitated patient with metastatic breast carcinoma.



Retroperitoneal approach: Below the diaphragm, exposure of the lumbar spine (L2-S1) can be performed through a retroperitoneal approach ([Fig. 10.3-3](#)). This often involves a flank incision, often with resection of the 11th or 12th rib. The patient lies in a decubitus or partial decubitus position. At risk here are the great vessels above and below the bifurcation of the aorta (L4-L5). The ureter crosses the operative field and must be identified and protected. The sympathetic chain may be damaged along the vertebrae, but the consequences of this are minimal. The presacral plexus further down may be injured and result in persistent retrograde ejaculation.

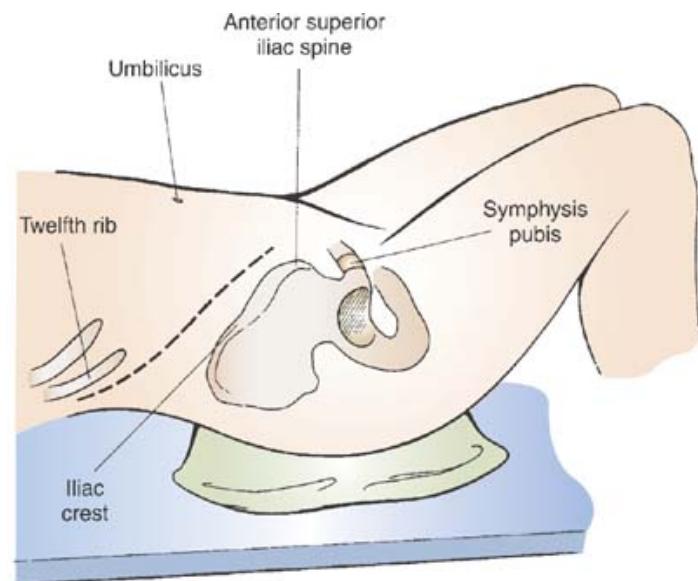


Figure 10.3-3. 3. Retroperitoneal approach to lumbar spine. (Reproduced with permission from Hoppenfeld S, deBoer P: *Surgical Exposures in Orthopaedics*. JB Lippincott, Philadelphia: 1984.)

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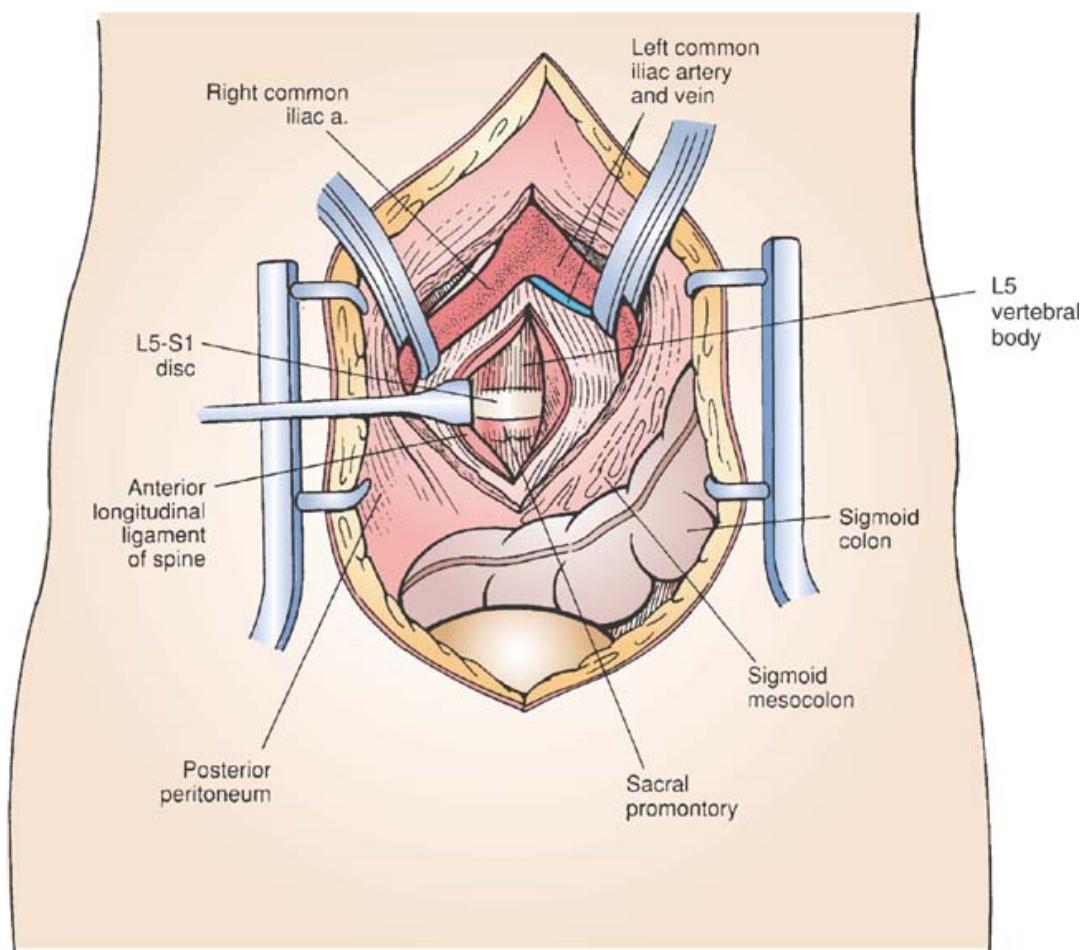


Figure 10.3-4. 4. Transperitoneal approach to lumbosacral junction. (Reproduced with permission from Hoppenfeld S, deBoer P: *Surgical Exposures in Orthopaedics*. JB Lippincott, Philadelphia: 1984.)

A Pfannenstiel's incision may be used to approach L5/S1 or L4/5. Regardless of the level of exposure, the operating table is used during the procedure to manipulate the spine for better exposure and to "lock in" implants, bone grafts, etc. Usually the area of the spine to be exposed is centered above the 'breaking' joint and kidney rests of the table ([Fig. 10.3-2](#)). After initial exposure, the table is angled in the center with the head and legs pointing down and the kidney rests elevated to open up the section of spine facing the surgeon. After the removal of the disc, abscess, or tumor, a reconstruction—using bone graft, metal implants, bone cement, or a combination of these—is performed. The table is then straightened; with the spine in neutral alignment, the stability of the reconstruction is tested by this maneuver, which may need to be repeated several times.

In some instances, the anterior reconstruction and fusion is followed with a **posterior fusion**, either immediately or after 5–7 d of convalescence. If done immediately after, the patient needs to be positioned prone on the operating table, and the second procedure done through a midline exposure. Sometimes anterior and posterior surgeries can be performed simultaneously by two surgical teams. The most common reason for a staged anterior/posterior procedure (in the United States) was scoliosis. Recent trends in degenerative lumbar disk surgery indicate that anterior and posterior fusion has become more common with some evidence suggesting better results in fusion and pain relief.

Variant procedure or approaches: When the L5 vertebra and sacrum need to be exposed widely, a **transperitoneal approach** may be needed. This involves a laparotomy or Pfannenstiel's incision, displacement of the bowels out of the pelvis, and exposure of the lumbosacral junction ([Fig. 10.3-4](#)). The patient is supine for this procedure and the surgical risks are similar, as with other intraabdominal approaches.

In a recent modification to the retroperitoneal approach, the patient is placed in the supine position. In this **supine retroperitoneal approach**, an incision is made in either a longitudinal or transverse fashion between the umbilicus (*Print pagebreak 970*) and the pubis. The rectus abdominus fascia is incised and the rectus abdominus is retracted medially or laterally, allowing access to the retroperitoneal space without violating the peritoneal cavity. The advantage of this approach over the transperitoneal approach includes decreased need for bowel manipulation, →↓ 3rd-space loss of fluid and ↓ heat loss.

Usual preop diagnosis: Degenerative disc disease; segmental instability; vertebral fractures requiring decompression; vertebral osteomyelitis or tuberculosis; neoplastic disease of the lumbar spine

Summary of Procedures

	Retroperitoneal Approach (Lateral)	Transperitoneal Approach
Position	Lateral decubitus, affected side up. The up hip and knee are flexed to relax psoas muscle and allow its reflection to expose the lumbar vertebral bodies.	Supine
Incision	Flank incision curving anteriorly to the lateral margin of the rectus abdominus (Fig. 10.3-3)	Pfannenstiel's above the pubis
Special instrumentation	Occasional use of anterior instrumentation to stabilize fractures or to reconstruct the spine when entire vertebrae are removed	
Unique considerations	In performing spinal reconstruction, manipulation of operating table is + A general bowel prep usually is essential to "lock in" graft or implant (see performed preop. above).	
Antibiotics	Cefazolin 1 g iv (+ gentamicin 80 mg iv, if indwelling bladder catheter already in place); exception is when infection is suspected and specific cultures are obtained intraop.	
Surgical time	3–6 h	The spine may be more or less stable



Closing considerations

after reconstruction, and patient usually transferred to bed prior to being awakened. Sudden jerking motions, etc., may dislodge graft or implant.

EBL

200–5,000 mL. Blood loss extremely variable. When bleeding occurs, it may be torrential from the aorta, vena cava, or iliac vessels and branches. In nontumor/infection cases, 200–400 mL is usual.

Postop care

Patients with degenerative conditions and elective surgeries normally recover in PACU and return to ward. Patients with infections, fractures, and tumors are usually observed in ICU for 24 h postop. Ileus for 24–72 h is usual; NG suction usually continues until bowel sounds and passing flatus are present. Generally, mobilization depends on final stability.

Mortality

Malignancy or sepsis: 1–2%

Elective: < 0.1%

Morbidity

In patients with malignancy, sepsis or fractures with cauda equina compression, overall serious complications: 25–50%

Cardiopulmonary failure

Neurologic deficit

Pneumothorax

Sepsis

Pain score

6

6

Patient Population Characteristics

Age range

Variable (infant–adult)

Male:Female

1:1, except more scoliosis surgery in females (1:4)

Incidence

Uncommon

Etiology

Infection (osteomyelitis, TB); trauma; congenital; neoplasia; idiopathic

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W Anesthetic Considerations for Spinal Reconstruction and Fusion

(Procedures covered: anterior reconstruction and fusion of thoracic, thoracolumbar, and lumbosacral spine)

▲ Preoperative

Patients presenting for spinal reconstruction commonly have either idiopathic or acquired scoliosis, a complex deformity involving both lateral curvature and rotation of the spine, as well as an associated deformity of the rib cage. Types of scoliosis include: idiopathic, congenital, neuromuscular, myopathic, traumatic, tumor-related, and mesenchymal disorders. The majority of cases are idiopathic, with a male:female ratio of 1:4. Normally, the cervical spine and lumbar spine are lordotic, while the thoracic spine is kyphotic. Surgery is indicated when the curvature is severe (angulation beyond 40° in the thoracic or lumbar spine⁷) or progressing rapidly. The primary purpose of the operative correction of scoliosis is not to straighten the spine, but to prevent further curvature from developing. The instrumentation is intended to stabilize the spine until bony fusion of the spine has occurred. After the fusion is solid (6–12 mo), the instrumentation may be removed if it is broken, causes protrusions or lumps in the back, or the patient is



having residual back pain. Nonscoliotic patients presenting for this surgery may have spinal instability as a result of trauma, metastatic carcinoma or infection (e.g., TB). These patients are usually healthy, apart from their underlying pathology. The patients with disseminated lung or breast cancer may need a careful workup with regard to respiratory, nutritional, and chemotherapeutic status. (See [Anesthetic Considerations for Lobectomy, Pneumonectomy, p. 275](#), or [Mastectomy, p. 652](#).)

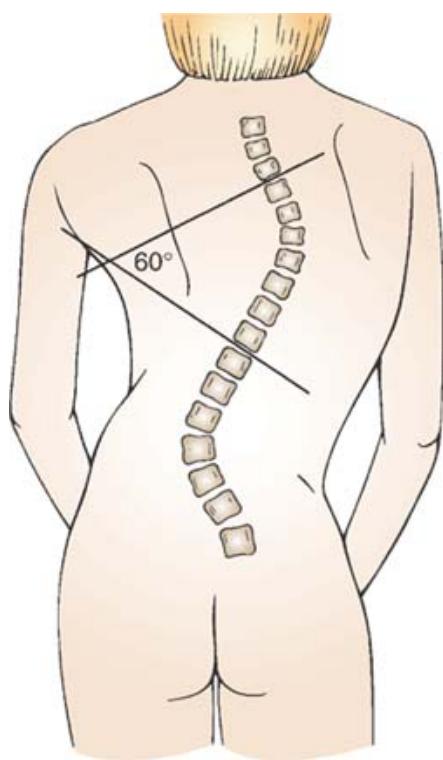


Figure 10.3-5. 5. Cobb angle.

Respiratory impairment proportional to angle of lateral curvature (Cobb angle) ([Fig. 10.3-5](#))

Cobb Angle:	30°–60°	60°– 90°	>90°
VC	↓ 25%	↓ 50%	↓ 70%
TLC	↓ 27%	↓ 37%	↓ 50%

Restrictive pattern: ↓ TLC + ↓ ↓ VC

- Respiratory**
- If VC >70% predicted, respiratory reserve is adequate.
 - If VC < 40% predicted, postop ventilation usually is required.

Expect further significant (~40%) ↓ VC immediately postop, requiring 7–10 d to resolve.

↑ RR + ↓ TV → ↑ dead space + ↓ alveolar ventilation → V/Q mismatch → hypoxemia.¹²

Patients with scoliosis of neuromuscular origin are more susceptible to aspiration and respiratory failure.

Tests: CXR; ABG; PFT; assess exercise tolerance by Hx.

↑ PVR (**NB:** independent of severity of scoliosis). High incidence of CHD and mitral valve prolapse.

Cardiovascular

Tests: ECG; ECHO—consult cardiologist if apical systolic murmur or other evidence of cardiovascular impairment is present.

SSEPs (posterior cord) and MEPs (anterior cord) will be monitored in most patients who are undergoing spinal reconstruction. Some surgeons, however, may request that the patient be awakened intraop, after completion of the instrumentation, but before closure of the wound, to

Neurological

ensure that no motor deficits have developed as a result of the correction. Movement of the toes or feet bilaterally is sufficient to verify intact motor function. Inform the patient preop that this test will be performed, that it will only take a few minutes, that the patient will not be in severe pain while doing the test, and that full anesthesia will be reinstated upon completion of the test. If focal neurological lesions exist preop as a result of disease (e.g., tuberculous spondylitis), their documentation is important to distinguish them from changes associated with correction.

When the Cobb angle is $> 25^\circ$, the degree of respiratory impairment will be significant, and the need for postop ventilatory support becomes more likely. Patients with muscular dystrophy may be more sensitive to myocardial depression from anesthetic agents and also may require postop ventilation 2° muscle weakness. Succinylcholine may cause severe rhabdomyolysis with hyperkalemia. These patients also may be at risk for MH.

Avoid use of Plt inhibitors 2 wk before surgery. Encourage autologous or directed-donor blood donations.

Have at least 2 U PRBCs available at start of operation. Consider use of low-volume Cell Savers (e.g., Medtronic Autolog). Discuss use of controlled \downarrow BP with surgeon. If anticipated blood loss is substantial, some institutions use isovolemic hemodilution by collecting 1–2 U blood at the start of anesthesia and replacing them with crystalloid or colloid solutions. Be aware that patients with previously placed spinal support (e.g., Milwaukee brace) for correction of scoliosis may have more blood loss than usual.

INR, PT, PTT, and Plt count preop. Hct the morning of operation or after induction of anesthesia if autologous donations have been made since, with modest blood loss and fluid therapy, the Hct may rapidly \downarrow to $< 26\%$.

Standard premedication (see [p. B-1](#)), if appropriate.

Musculoskeletal

Hematologic

Laboratory

Premedication

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Intraoperative

Anesthetic technique: GETA. For pediatric cases, preheat room to 78°F . For operations in the prone position, use a wire-reinforced tube to prevent kinking and airway obstruction. If a transthoracic approach is used, a DLT is necessary.

Induction

Standard induction ([p. B-2](#)). A DLT may facilitate surgical access in the patient undergoing an anterior correction. The smallest available DLT is size 28 Fr (OD = 8.9 mm), typically suitable for a child aged 12–14 yr.

Standard maintenance ([p. B-2](#)). Monitoring of SSEP and MEP recordings are standard of care and performed in virtually all patients undergoing correction for scoliosis. For optimal monitoring a TIVA is preferred, thereby avoiding any inhalation anesthetics. The usual TIVA drugs are propofol 75–200 mcg/kg/min and remifentanil 0.02–0.5 mcg/kg/min. The larger doses are used at the start of anesthesia and surgery, and gradually lowered as a blood level of the agents is established. It is advisable to administer midazolam 3–5 mg at the start of anesthesia to minimize any possibility of recall in the early phase

Maintenance

Emergence

of anesthesia.

The patient's trachea usually is extubated at the conclusion of the operation, unless there is a question of lung function following a transthoracic approach and OLV. Some surgeons may place an epidural catheter before closure for postop pain management or perform intercostal injections for the transthoracic approach. Prior to emergence, scoliosis patients usually are fitted with a plaster mold to be used as a permanent brace that will be worn for several mo postop. Transfer from the operating table to bed must be smooth and gentle.

Anticipate substantial blood loss with scoliosis surgery from extensive dissection of muscles from bony spine; less so with isolated thoracic fusion. It may vary from 25–100% of the patient's blood volume, although blood loss is usually less with the anterior approach (Dwyer's). Colloid is preferred since it will remain intravascular until metabolized.

Low-volume units (e.g., Medtronic, AutoLog) are best.

Consider maintaining BP \geq 20% below the lowest preop values to minimize blood loss during dissection. Generally maintain MAP $>$ 60 mmHg in young, healthy patients, and $>$ 85 mmHg in older patients, for spinal cord perfusion. Once dissection is complete, higher BP values acceptable. Maintain UO at 0.5–1 mL/kg/h during controlled hypotension.

CVP monitor helpful in selected, older patients to assess fluid Rx. Trends in CVP may be more reliable than measurement of UO to assess changes in volume status in patients in the prone and lateral positions.

Prone: Place head on cushioned head holder with cutout for eyes, nose, chin (e.g., Andrews Gentle-Rest pillow). Make certain that none of the face rests on bed. elbows, knees, feet.

Lateral: Place head on donut in neutral position. Pad both arms in neutral position.

Blood and fluid requirements	IV: 14–16 ga \times 2 NS/LR @ 6–8 mL/kg/h not to exceed 40 mL/kg
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Hetastarch 6% \geq 20 mL/kg or albumin prn
Warm all fluids.
Humidify gases.
T&C 2–4 U PRBCs.
 \pm Cell Saver

Position to prevent venous engorgement.
 \downarrow MAP to 60–70 mmHg.
 \pm \downarrow Hct to 25–28%.

Standard monitors ([p. B-1](#))
Arterial line
CVP line
Urinary catheter
 \pm SSEP

and pad pressure points.
eyes, neck.

Control of blood loss

Monitoring

Positioning

30 min advance warning from surgeons is needed (sevoflurane).

- Decrease inhalational agents.
- Reverse muscle relaxants (and narcotics, if necessary).
- Monitor train of four.
- Request hand squeeze; if present, elicit bilateral foot movement.
- Reinduce anesthesia with STP (2–3 mg/kg) or propofol (0.5–1 mg/kg).

Wakeup test

The wake-up test assesses integrity of motor pathways in the ventral cord. Uncontrolled patient movement during wake-up test can result in accidental extubation or dislodgement of the spinal instrumentation. Unrestrained inspiratory efforts may provoke venous air embolism. The anesthesiologist must be prepared to rapidly reanesthetize the patient.

Dangers:

Air embolus
Dislodgement of spinal instrumentation
Accidental extubation

SSEP and MEPs

SSEP: Dorsal cord function only
MEPs: Ventral cord function

SSEP and, more recently, MEP are being used routinely. The technician needs to know when there are substantive changes in doses of inhalation anesthetics or ventilation. Optimal EP recordings are obtained with TIVA anesthesia. One can discontinue TIVA at the start of closure and substitute sevoflurane until the operative procedure is concluded. Have fentanyl or meperidine ready for analgesia as the remifentanil effect wanes.

SSEP indications of spinal cord ischemia should be treated by restoring normal BP and by ↓ cord traction. Prompt transfusion may be necessary and blood should be available in the room (2–4 U PRBC).

Complications

Spinal cord ischemia
Massive blood loss
Fat embolism

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Postoperative

Complications

Pulmonary insufficiency
Hypothermia
Pneumothorax
Dislodgement of internal fixation

Postop ventilation may be required in patients with severe respiratory impairment (see Preoperative Considerations, above). In addition, thoracotomy, surgical trauma to the diaphragm and fat embolism may further ↑ the risk of postop pulmonary insufficiency. Careful handling of patient in transfer is mandatory.

**Pain management****Tests****Neurologic sequelae²⁷****PCA ([p. C-3](#))**

Intrathecal morphine 0.1–0.25 mg by surgeon intraop, dependent on age of patient

Thoracic/lumbar epidural opiates

CXR; ABG; Hct

Neurologic sequelae probably remain the most feared complication, and it is important to document postop neurologic exam.

Pain is a significant problem for postop scoliosis patients. Most need analgesia × 3–4 d. Preop consultation with patient (and parents) about different pain management techniques is important.

See [p. C-2](#).

for pneumothorax and line placement.

Suggested Readings

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