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The lateral extracavitary approach to the thoracic and lumbar spine

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The lateral extracavitary approach (LECA) to the thoracic and lumbar spine was originally developed by Alexander [1] and Capener [2] for the treatment of tuberculous spondylitis [3]. The original procedure was modified to expand its application to other anterior spinal column pathologic findings (eg, fractures, infection, thoracic disk disease) and to allow for the placement of posterior instrumentation [4–12]. This modified LECA differs from Capener's spinal exposure in the configuration of the skin incision and in the mobilization of the erector spinae muscle group, which are dissected along the lateral border and retracted medially along the length of the incision [3,5].

The LECA to the thoracic and lumbar spine can be used for the removal of metastatic spine tumors causing anterior or lateral spinal cord or cauda equina compression. It provides lateral exposure to the thoracic and lumbar vertebrae without entering the pleural or abdominal cavity (extracavitary) and enables the surgeon to visualize the anterior dural surface better than with other posterior lateral exposures. In addition to ventral spinal cord decompression, the LECA allows for the placement of posterior instrumentation without the need for a second incision. For circumferential metastatic spinal cord compression, the LECA can be performed bilaterally or combined with a less extensive contralateral transpedicular decompression or costotransversectomy. Circumferential decompression of the spinal cord is difficult, if not impossible, to accomplish with classic anterior approaches like thoracotomy and retroperitoneal approaches. Access to the thoracolumbar junction using an anterior lateral approach (thoracotomy or thoracoscopy) requires the takedown of the diaphragm, which is completely avoided using the LECA.

In the treatment of metastatic spine disease, the LECA is ideal for patients requiring resection of one vertebral segment for spinal cord decompression, reconstruction, and stabilization. It can also be used for patients with involvement of up to three vertebral segments. Anterior reconstruction can be performed with cages, methylmethacrylate, or bone graft and combined with an anterior-lateral plating system.

The LECA is essentially performed using the same steps from T4 to L3, and with modifications based on regional anatomic characteristics (Figs. 1 and 2), it can be extended to T2 and S1 [5,13–15].

Preoperative evaluation

For patients with metastatic spine tumors, good preoperative imaging studies are paramount in determining the surgical strategy for spinal cord decompression and reconstruction. These studies should include plain radiographs and computed tomography (CT) scanning to determine bone quality, deformity, pathologic fracture, and to what extent spinal cord compression is caused by

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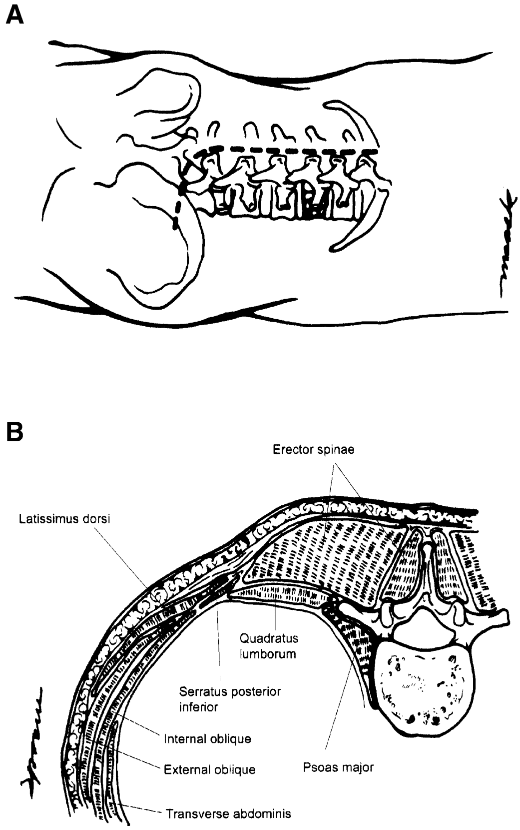

Fig. 1. Illustration of the hockey stick incision (*A*) and cross-sectional anatomy of the lumbar spine (*B*).

bony fragments. CT can also assist with the selection and placement of spinal instrumentation. Pedicle screw fixation for malignant spine disease is becoming increasingly popular and has been shown to be safe in patients with cancer [16]. CT scanning can be useful in planning for the placement of pedicle screws, because the diameter and angulation of the pedicle can vary between patients.

Magnetic resonance imaging (MRI) has become widely available and is the study of choice to evaluate acute spinal cord compression (Fig. 3). Sagittal MRI of the spine with and without gadolinium reveals bone, epidural, and paraspinal tumor involvement. The extent of epidural spinal cord compression can be readily assessed. Metastatic tumor in the marrow of the vertebral body is best visualized with T2-weighted images or short tau inversion recovery images, which enhance the contrast between lipid marrow (hypointense) and tumor (hyperintense). The ports of prior spinal radiation treatment can be seen as

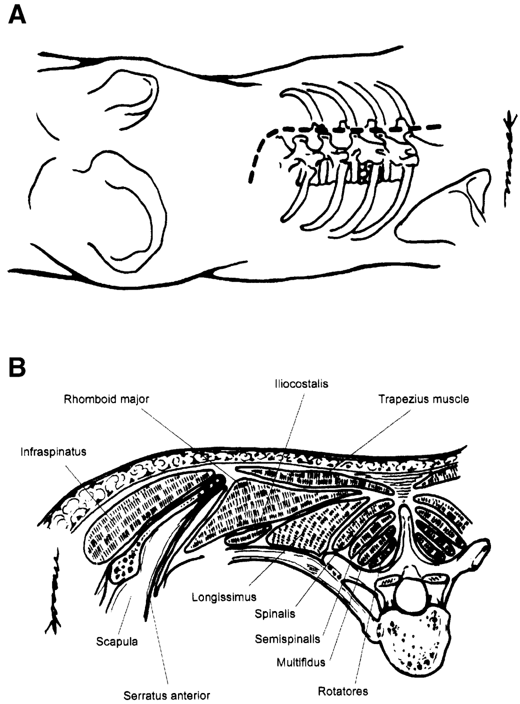

Fig. 2. Illustration of the hockey stick incision (*A*) and cross-sectional anatomy of the upper thoracic spine (*B*).

hyperintense vertebral changes on T1-weighted images. Myelography and postmyelogram CT can be useful in patients with prior surgery, where the metallic artifact of the instrumentation may interfere with MRI quality.

Preoperative spinal angiography is commonly performed, because many metastatic tumors benefit from preoperative embolization. Renal cell carcinoma, melanoma, and the rare thyroid cancer metastasis should be highly considered for embolization. In addition, the use of the Cell Saver system (Haemonetics, Braintree, MA) is not recommended in patients with cancer, making embolization an important adjunct to minimize blood loss. Spinal angiography is limited to the area of surgery, and the artery of Adamkiewicz can be found most frequently between T6 and T12. The side of the surgical approach can be adjusted to protect the artery but only if that does not compromise optimal exposure for spinal cord decompression.

The timing of surgery in metastatic spine disease depends on the neurologic status of the patient. Neurologically intact patients can be scheduled electively should there be an indication for surgery like an unstable pathologic fracture.

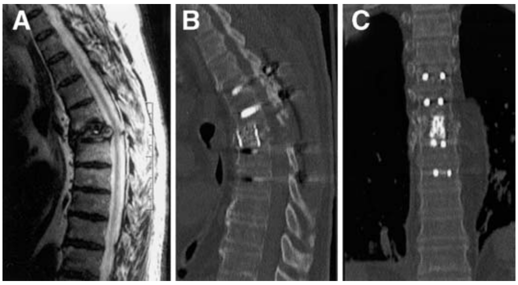

Fig. 3. The patient is a 60-year-old individual with multiple myeloma who presented with progressive walking difficulties 4 weeks after completion of radiation therapy for a T6 metastatic lesion. (*A*) Preoperative magnetic resonance imaging scan demonstrating T6 tumor with epidural spinal cord compression. (*B*) Postoperative sagittal reconstructed computed tomography (CT) scan after a lateral extracavitary approach demonstrating thoracic pedicle screw and titanium cage placement. (*C*) Postoperative coronal reconstructed CT scan illustrating the central position of the cage.

Patients with neurologic deficit, bowel or bladder dysfunction, or, in particular, motor weakness are scheduled for more urgent surgery.

There is good evidence, including class I data, that steroids are beneficial adjunctive therapy in patients with metastatic epidural spinal cord compression [17]. Dexamethasone or methylprednisolone frequently stabilize neurologic deterioration and allow for a coordinated preoperative workup and surgical planning. Based on a review of the current literature, an appropriate regimen of dexamethasone would consist of an initial bolus of 10 mg, followed by a maintenance dose of 16 mg/d that is tapered after decompression over several weeks [17]. In a patient with an unknown primary site, steroids should be avoided, if possible, until tissue for diagnosis has been obtained.

For patients with metastatic spine disease, other considerations include their medical comorbidities, life expectancy, and prior treatment, such as radiation [18]. The Tokuhashi score can be used to estimate survival for patients with metastatic spine disease [18,19]. Patients who have scores ≤ 5 generally have an average survival of less than 3 months, whereas patients who score ≥ 9 survive 12 months or more (Table 1). Radiation therapy is associated with poor surgical outcome with regard to wound complication and neurologic function [20,21]. In particular, so-called "rescue operations," which occur with a patient who deteriorates during radiation, are frequently associated with unfavorable outcomes.

Table 1
Tokuhashi score

	Score
1. General condition (Karnofsky)	
Poor (10–40%)	0
Moderate (50–70%)	1
Good (80–100%)	2
2. Number of extraspinal bone metastases	
≥ 3	0
1–2	1
0	2
3. Number of metastases in the spine	
≥ 3	0
2	1
1	2
4. Metastases to the major internal organs	
Irremovable	0
Removable	1
No metastases	2
5. Primary site of the cancer	
Lung, stomach	0
Kidney, liver, uterus, others, unidentified	1
Thyroid, prostate, breast, rectum	2
6. Myelopathy	
Complete	0
Incomplete	1
None	2

The role of neurophysiologic monitoring remains to be determined. Its value in patients with complete deficits or severe motor weakness (less than 2/5) is limited. The LECA allows for direct visualization of the spinal cord during decompressive procedures, making neurophysiologic monitoring an adjunct rather than a necessity.

Operative technique

Positioning

The patient is placed into the prone position after the placement of intravenous and arterial access and an indwelling Foley catheter. Although a standard operating table with chest rolls can be used, we prefer a Jackson frame. It decreases the blood loss secondary to venous pressure elevation from abdominal and chest pressure associated with prone positioning. In addition, it provides more space for intraoperative imaging equipment, such as fluoroscopic instrumentation. The Jackson table can also be safely rotated 20° to 30°, which allows for maximal exposure of the ventral dural sac across the midline. The patient's arms can be tucked in at the sides, although it is preferred to position the arms above the head to improve radiographic imaging. All potential pressure points are carefully inspected and padded to avoid skin breakdown, nerve injuries, and plexopathies. For surgery in the upper thoracic spine, it is useful to place the patient in a three-point head holder. Neuromonitoring can be used, but the leads are best placed before positioning and connected to the monitoring equipment after the turning of the patient.

Incision location

The skin incision is marked after the patient is positioned. Using fluoroscopy and a metallic marker, the level of pathologic findings is identified. A curved hockey stick–shaped incision with a vertical portion and lateral limb is outlined (see Figs. 1A and 2A). The hockey stick typically extends laterally for approximately 10 to 12 cm toward the side with the most tumor involvement. The side and level where the artery of Adamkiewicz enters the spinal canal is avoided whenever the pathologic findings permit. The vertical portion of the hockey stick depends on the type of instrumentation that is used for stabilization. For transpedicular fixation, one or two levels above and below the vertebral segment to be resected is sufficient. If the pedicles are not suited for pedicle fixation, hooks can be used, but this requires a longer vertical incision.

Exposure

The outlined incision is carried through the subcutaneous tissue to the thoracolumbar fascia. At this point, a bilateral subperiosteal dissection is performed to expose the posterior elements of the spine for laminectomy and placement of instrumentation. After the exposure of the posterior elements, the lateral myocutaneous flap is developed (see Figs. 1 and 2). The thoracolumbar fascia, subcutaneous tissues, and skin are incised together along the lateral angled portion of the incision. After elevation of the myocutaneous flap, a plane along the lateral border of the erector spinae muscles is identified. The muscles are elevated as a group and retracted medially along the extent of the incision. This can be accomplished with self-retaining retractors or a table-mounted system.

To achieve lateral exposure of the thoracic or thoracolumbar spine, the ribs above and below the level of the vertebrectomy need to be removed. For tumors at L1 or L2, removal of the twelfth rib facilitates the exposure. In the thoracic spine, the ribs are removed by elevating the periosteum with a Doyen dissector. The rib is then cut and

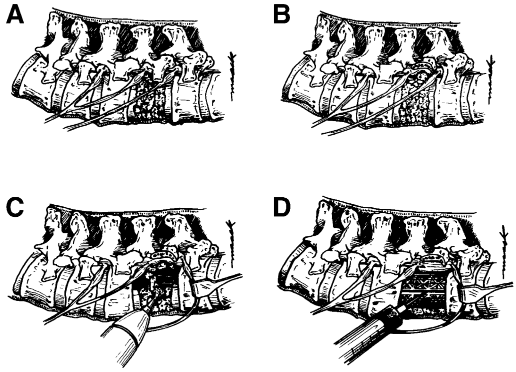

Fig. 4. Lateral extracavitary approach to the spine. (*A*) Lateral view of the spine with spinal nerves and vertebral body with metastatic tumor. (*B*) Lateral view of the spine after partial laminectomy and resection of the ipsilateral pedicle to expose the area of spinal cord compression. (*C*) Partial corpectomy and tumor resection for spinal cord decompression. (*D*) Vertebral body replacement with a titanium cage and polymethylmethacrylate.

removed from the costotransverse and costovertebral joint. The neurovascular bundle is identified and dissected to the vertebral foramen. In the lumbar spine, the spinal nerves are identified after resection of the transverse process and can then be dissected to the vertebral foramen. The lumbar nerves are carefully preserved and dissected. In the thoracic spine, the nerve can be ligated, which can make the exposure of the lateral vertebral body easier.

Anterior spinal cord decompression and reconstruction

After the identification of the diseased vertebral body, a blunt dissector is placed into the disks and the level is confirmed with fluoroscopy (Fig. 4). At this point, the table is rotated 20° to 30° away from the surgeon. The pedicle is then resected, exposing the lateral dural sac and tumor (see Fig. 4B). After that, the intervertebral disks are completely removed. A central corpectomy is then performed with either osteotomes or a high-speed drill (see Fig. 4C). The posterior vertebral wall, along with the epidural tumor, is pushed away from the spinal cord into the corpectomy defect and subsequently removed. Bleeding is controlled with standard hemostatic agents. After the anterior decompression is completed, it can be inspected with a dental mirror or an endoscope. For vertebral body reconstruction in metastatic spine disease, either methylmethacrylate or a titanium cage can be used (see Fig. 4D). This can be supplemented with an anterior lateral plate if posterior fixation alone is insufficient.

Closure and postoperative care

The wound is carefully closed in layers. A Hemovac drain (Zimmer, Warsaw, IN) is left in the paravertebral region for 24 to 48 hours. If the pleura was entered, placement of a small chest tube should be considered for 24 hours. The patient is usually extubated in the operating room and spends 24 hours in the intensive care unit. Postoperative chest and spine radiographs are routinely obtained. The proper position of the instrumentation and titanium cage is confirmed with postoperative CT (see Fig. 3B, C). Cancer patients are not routinely placed in a brace. Complications associated with the LECA include excessive blood loss, long operating time, and coagulopathy and wound complications. In particular, in cancer patients with malnutrition and prior radiation, wound breakdown and infections are common. Blood loss can be decreased with the use of the Jackson table, efficient surgery, and preoperative embolization.

Summary

The LECA is a technically challenging procedure with a steep learning curve. It is one of the most versatile approaches to the spine, however, with a logical sequence of maneuvers that can be combined to adapt the LECA for many different spinal procedures that need to be performed for decompression of the spinal cord and reconstruction of the spinal column in cancer patients.

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