Laminotomy and total reconstruction of the posterior spinal arch for spinal canal surgery in childhood

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Kyphosis, anterior subluxation, and instability of the spine are reported as postoperative complications of multiple level laminectomies in children. The surgical procedure of multiple level laminotomies is proposed as an alternative. Indications in infants and children, the surgical technique, and the postoperative management are presented. The goal is preservation of the normal architecture of the spine in patients who are still developing.

KEY WORDS • multiple level laminotomy • multiple level laminectomy • pediatric neurosurgery • kyphosis • spine instability

MULTIPLE level laminectomies are a currently accepted surgical approach to spinal cord lesions. In most adult patients the procedure is not followed by evident impairment of spine stability. In children, however, multiple level laminectomies may cause kyphosis, anterior subluxation, and instability of the cervical or thoracic and lumbar spine.

Several structures provide for the stability of the spinal column: intervertebral joints, laminae, ligamentum flavae, spinous processes, interspinous and supraspinous ligaments, and paraspinal muscles. In the adult, stability depends mostly on the intervertebral joints, while the role of the other structures is relatively less important. The vertebrae of the child are developing structures for which balanced mechanical stimulations are necessary to insure normal growth. Spinal deformity or instability result from conditions in which bone and ligamentous deficiencies or neuromuscular imbalances occur. Such conditions may be caused by multiple laminectomies that destroy growing bone structures (laminae and spinous processes), that separate interlaminar and interspinous ligaments from adjoining vertebral arches, and substitute scar tissue for insertion of paraspinal muscle masses onto the laminae and spinous processes.

The purpose of this paper is to present an alternative to laminectomy for complete exposure of the spinal canal that allows anatomical reconstruction of the vertebral arches and reinsertion of interspinous ligaments and paravertebral masses.

Clinical Materials and Methods

Indications for Surgery

The criteria for performing a laminotomy include the extent of the surgical procedure, the age of the patient, and the nature of the lesion. In children under 1 year of age we per-
form a laminotomy even if only one level is to be exposed, in children between 1 and 15 years for two or more levels, and in patients older than 15 years when three or more levels are to be exposed. Independent of the age of the patient or the extent of the intraspinal lesion, we perform laminotomy in all patients with trauma, syringomyelia, hydromyelia, and tuberculosis. No attempt is made to perform laminotomy in patients with extensive epidural metastases.

Surgical Technique

The exposure should extend from one full vertebra above through one full vertebra below the planned extent of the laminotomy. Thus, if a laminar flap is to be reflected from C-3 through T-4, one should expose the laminae from C-2 through T-5. Muscle and ligamentous attachments are separated from the spinal arches leaving the periosteum and interspinous ligaments intact. The dissection is carried laterally to just beyond the articular facets, with care being taken not to open into the joint or strip the capsular ligaments. The closure is facilitated if one leaves a ruffle of muscle and ligament on the spinal apophyses.

The interspinous ligament between the most inferior spine to be removed and the most superior one to remain is then cut cleanly with a No. 15 blade until the spinal canal is entered or epidural fat extrudes, at which time the sharp dissection is extended through the yellow ligaments bilaterally. If these ligamentous incisions are made along the bone surface, it may be impossible to reapproximate them at the time of closure. The same procedure is then repeated at the ligamentous interspace between the posterior (laminar spinous) vertebral arches of the most superior arch to be removed and the most inferior one to remain.

The laminar osteotomy is made with a high-speed drill along an imaginary line separating the pedicle from the lamina (Fig. 1). Insertion of a curved dissector (Penfield No. 3) beneath the laminae assists the surgeon in identifying the medial surface of the pedicle, and may be used to protect the epidural vessels when the laminotomy is begun. The laminotomy is best made by using the burr in brush-like strokes along the surface of the lamina in the direction of the planned line, rather than using it as a perforator extending through the full thickness of the lamina each time. This latter technique is dangerous, but the former one is safe. A fine-tipped sucker, inserted into the laminotomy groove, and magnification allow the surgeon to see the full extent of his field. When the laminar incision is complete, the lamina may be easily moved by wedging a small dissector (Penfield No. 4) into the laminotomy groove and twisting it. This procedure is continued inferiorly from one laminotomy to another along one side and then repeated on the other side.

When the laminae are all freed, the laminar flap, consisting of laminae and the intact interspinous and yellow ligaments (only the most superior and inferior ligaments are incised), may be reflected superiorly and then removed (Fig. 2). The most inferior spinous process is lifted gradually, exposing the loose connective tissue and small vessels in the epidural space. Packed cotton strips or fluffy cotton wads inserted along the ventral surface of the vertebral arch assist the dissection and protect the dura. Sharp dissection of the loose
FIG. 2. Drawing shows the cutting of the yellow interlaminar ligaments and epidural loose connective tissue (2), while the bone flap (1) is progressively freed. The dura mater (3) and the transverse vertebral processes (4) are also recognizable.

connective tissue minimizes stretching. After the laminar flap is removed, it must be kept in physiological saline at 37°C, so that the ligamentous tissue will not dry and shrivel.

After the interspinal surgery has been completed and the dura closed, the laminar flap is brought into its anatomical position. Symmetrical drill holes made at either side of the laminotomy incision are positioned across from one another starting with the most inferior laminae and then progressing superiorly, and suture material previously passed through the openings is tied down (Fig. 3 left). As this is done in an inferosuperior direction, the laminae are easily brought into their normal anatomical position. The yellow and interspinous ligaments at the inferior and superior extremities are then sewn into place, thereby completing the reconstruction of the laminar flap (Fig. 3 right). After the retractors are removed, the paravertebral muscle masses are allowed to assume their anatomical position. They are then sewn into the individual interspinous and supraspinous ligaments, thus facilitating balanced movements and stability in the region of the laminar flap after healing.

Postoperative Treatment and Follow-up

The postoperative treatment consists of appropriate immobilization of the patient with a thoracic or lumbosacral cast for the corresponding spine segments, or a four-poster cervical collar for the cervical spine. Serial x-ray control films are taken from the first days after surgery, and monthly thereafter. At the third, sixth, and twelfth month, supplementary x-ray films are also taken of the spine in extension and flexion positions. Once there is x-ray evidence of complete healing across the osteotomy site, no further x-ray films are taken and the child may resume normal activity.

Illustrative Case Reports

Case 1

This 3-year-old girl developed normally until 15 months of age when curvature of the
spine and weakness were first noted. A diagnosis of intraspinal tumor was made by myelography in another hospital, and the child had a thoracic laminectomy (report not available). The paraparesis improved slightly, but neck movements became progressively more limited and the cervicothoracic kyphosis worsened. At the time of admission to our service 6 months later, she had a kyphosis at the cervicothoracic levels, and a scoliosis at the lumbosacral level. Extension of the head provoked severe pain along the entire spine. There was paraparesis with slight spasticity and bilateral extensor plantar responses. A combined lumbar and cisternal myelogram showed blockage from L-2 to C-1. A laminotomy from T-5 to L-3 showed the cord to be uniformly tumefied, but no cyst or solid tumor was identified. The dura was left open and the laminar flap was replaced and anchored into position. The child’s condition improved.

She was readmitted 5 months later because of severe neck pain, irritability, and weakness in the upper and lower extremities. She had poor head control and now had a sensory level at C-4. A second stage laminotomy from C-1 to T-3 was performed. When the transparent dura was opened, the spinal cord appeared to be under severe tension. A myelotomy through the posterior longitudinal fissure allowed xanthochromic fluid to shoot out under pressure. The myelotomy was extended from T-3 to C-1, and revealed a cystic tumor (astrocytoma Grade I) occupying the area from C-2 to T-4. The dura was closed and the bone flap anchored into place. The paravertebral muscle masses were sewn to their appropriate spinous and interspinous ligaments after the yellow ligaments of T-3 had been anchored to T-4 and the arch of C-1 anchored to the atlantooccipital membrane. Plain films and tomograms of the cervical and upper thoracic regions taken after 13 months revealed good healing and alignment of the laminotomy flap (Fig. 4).

Case 2

This 12-year-old boy was kicked in his right loin while playing football approximately 5 months prior to admission; on his
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Fig. 4. Left: This 3-year-old girl with a spinal cord tumor had a laminotomy from C-1 to T-3. Postoperative cervical spinal x-ray film showed good alignment of the lamina flap. Some Pantopaque remains from previous myelogram. Right: Oblique tomogram of the cervical spine shows good healing from C-1 to C-7.

A laminotomy removing the laminae of L-4 and L-5 en bloc, was performed. A dislocation was found at the zygapophyseal joint between L-4 and L-5 on the right. The superior articular facet of L-5 on the right was fractured and the articulation between L-4 and L-5 on the right was dislocated. In addition to this, the yellow ligament was buckled on itself, markedly displacing the fifth lumbar root on the right and compressing the dural sac medially and to the left, thereby causing severe compression of the fifth lumbar root and narrowing of the spinal canal. Both these structures were freed by the removal of the fractured superior articular process of L-5. The laminar flap was then anchored back into position and the muscle attachments sewn back into place. At the first, second, and third month, follow-up x-ray films of the spine

way home he suffered the onset of severe pain in his right leg. Since that time, the pain in the distribution of the sciatic nerve on the right had been constant and intractable. The boy walked with a stiff leg and developed a minimal compensatory scoliosis, even though he was almost incapacitated by the pain. Objective examination revealed straight-leg raising positive at 10° on the right and tenderness along the sciatic nerve over the right gluteus muscle mass. There was also point tenderness at L4–5, an absent ankle jerk on the right, and weakness of the extensor muscles of the right great toe and foot. X-ray films of the spine revealed only a mild scoliosis. Myelography revealed the presence of a narrowed spinal canal and compression and medial displacement of the fifth lumbar nerve root on the right.
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showed progressive healing and perfect alignment of the spine.

Discussion

Laminectomy is a destructive procedure indicated when there are intraspinal metastases compressing the cord or cauda equina. When the intraspinal lesion is traumatic, benign neoplastic, or a congenital malformation (such as diastematomyelia, diplomyelia, or dermoid sinus tract) laminectomy may further weaken the spinal column. Decompressive laminectomy for the drainage of epidural tuberculous abscess makes subsequent fusion, the treatment of choice, difficult or impossible. Whenever a limited laminectomy (one or more levels) is performed in a child, kyphosis and scoliosis may develop and become difficult clinical problems necessitating further fusion.

The reflection of a free laminar flap over the intraspinal lesion allows as complete an access to the spinal canal as the most extensive laminectomy, since the lateral border of the laminotomy is at the medial surface of the pedicle. Multiple level laminotomy flaps provide access to the entire spinal canal (C1–T3, T5–L3, L2–L5, in our experience), thereby allowing surgical removal of the most extensive lesions without permanently weakening the vertebral column or destroying the growth center in the posterior portion of the spinal arch.

The removal of multiple laminae in a single laminar flap is a tedious procedure, and requires considerably more time than a laminectomy. It is not a dangerous procedure since magnification (loupes or microscope) and high-speed drills permit one to separate the laminae and yellow ligaments with precision. It is important to immobilize the patient for appropriate periods of time, depending upon his age and the extent of laminotomy, to assure bone bridging and minimize the possibilities of pseudoarthrosis.

References


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