THE TREATMENT OF RUPTURED LUMBAR INTERVERTEBRAL DISCS BY VERTEBRAL BODY FUSION

I. INDICATIONS, OPERATIVE TECHNIQUE, AFTER CARE

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WHENEVER the subject of the treatment of ruptured lumbar intervertebral discs is discussed, one always finds controversy and disagreement among neurosurgeons and orthopedic surgeons on the advisability, indication and necessity of a spinal fusion in these cases. The reason for this controversy is obviously the fact that many patients who have had operations for the removal of a ruptured intervertebral disc have not been cured of their symptoms or have returned at a later date with a recurrence of them.

Dandy stated very positively that spinal fusions were absolutely unnecessary and that one had only to curet out the nucleus pulposus and the involved joint would fuse itself! More conservative neurosurgeons believe that if a patient has leg pain predominantly, simple removal of the disc may be sufficient. When the disability is primarily low-back pain and the patient has abnormal facets or arthritic spur formation giving evidence of an unstable back, a fusion operation is indicated. Most orthopedic surgeons are in favor of combining the removal of the herniated portion of the ruptured disc with a fusion operation. In the light of personal experience in the surgical treatment of ruptured lumbar discs since 1937 and in studying the results of others, it is my opinion that more patients will be permanently cured of their symptoms if removal of the ruptured disc is accompanied by bony fixation of the involved vertebral joint. The writer is one of few neurosurgeons who seriously believes that all lumbar disc operations should be accompanied by a spinal fusion, if the fusion is done between the bodies of the vertebrae.

The two types of disabling pain associated with ruptured intervertebral discs are produced by various pathological factors. (1) The low-back pain is primarily caused by collapse of the intervertebral disc and the resultant loose, unstable vertebral joint. The torn fragments of the disc may move about within the intervertebral space. If loose fragments shift to one side of the interspace, they may interfere with the normal articulation of one vertebral body upon the other, producing changes of alignment of the spine, limitation of movement and pain. There may result from this situation muscle spasm, which will also contribute to the back pain. Overriding of the articular facet resulting from collapse of the disc causes traction upon the joint capsule, which is painful.

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The pain in the lower extremities may occur with compression of the nerve root at the intervertebral foramen. One or all of the following abnormal conditions may be responsible for nerve root pressure: (a) Herniation of the torn fragments of the intervertebral disc or bulging backward of the nucleus pulposus into the spinal canal. (b) Narrowing of the intervertebral foramen by subluxation of the articulate facets following collapse and narrowing of the intervertebral space. (c) Proliferation of bone along the margins of the body of the vertebrae posteriorly, (osteophytes) encroaching upon the intervertebral foramen. (d) Hypertrophy of the ligamentum flavum which, with the facet, forms the posterior boundary of the intervertebral foramen. This latter condition, however, is questioned by some writers.

In the medical literature of the past 15 years on the treatment of ruptured intervertebral disc, most emphasis has been placed upon the relief of the sciatic pain by removal of the mechanical pressure upon the nerve root. The primary pathology, which is a damaged or broken joint of the spine, has received less attention. In recent years, however, more and more spinal fusion operations are being advocated, indicating a trend toward treatment of the joint pathology. Obviously both causes of disability must be considered and treated if one expects to completely cure the patient of all symptoms. First, one must remove all abnormal mechanical factors that may compress the nerve root; and second, one must immobilize the broken, movable, painful vertebral joint. Removing the herniated fragments of the intervertebral disc without immobilizing the joint disregards the primary pathology and, likewise, fusion of the spine without thorough investigation and decompression of the involved nerve root cannot be expected to relieve the patient of the radiating pain in the lower extremities.

In 1944, after the appearance of a report by Shinniers and Hamby, the writer made a follow-up survey of 162 patients who had been operated upon for ruptured disc in the previous 5-year period. They had all had hemilaminectomies with simple removal of the protruded disc. The number of patients who had continued to complain of low-back pain or recurrence of sciatica was impressive. Over 70 per cent of them had returned to the office at one time or another after operation with complaints referable to their ruptured disc. [Of these patients 32 or 19.7 per cent subsequently had a second (fusion) operation.] It was concluded that any operative procedure that could not promise the patient at least 50 per cent chance of a complete and permanent cure was not worth while. The writer therefore set about to devise some procedure that could permanently cure these patients without disability. It seemed logical that to correct the underlying cause of the low-back pain, i.e., the collapse of the intervertebral disc, an operative procedure should be directed toward immobilizing the abnormal vertebral joint.

A series of patients were operated upon with an orthopedic surgeon. A posterior (Hibbs) type of spinal fusion was done after removal of the herniated fragment of disc. We were not satisfied with our results. It never
seemed physiologically correct to me to attempt to immobilize a single vertebral joint; for example L4 and L5, by bridging a graft over the spinous processes and laminae (non-weight-bearing surfaces) of the joint above and the joint below. This type of fixation operation gave a stiff back, which was very often painful, and failure of fusion (pseudo-arthrosis) occurred all too frequently. We had the same experiences as Love;17 2 of our patients had a recurrent herniation of the same disc with return of the sciatica after a posterior spinal fusion had been done, and in 3 patients a ruptured disc developed above a spinal fusion.

The ideal operation, mechanically efficient, for the fixation of a single vertebral joint after rupture of an intervertebral disc should be one directed toward restoring the intervertebral space, if possible, and at the same time immobilizing the adjacent vertebral bodies. Fusion of the chief weight-bearing part of the vertebra—the bodies—by a strong intervertebral graft wedged into the interspace to replace the ruptured disc seemed to be the logical procedure. The operation of vertebral body fusion was begun in 1943, and almost every patient with ruptured lumbar disc operated upon since 1944 has been treated in this manner.

The author was not aware then of the experience of Van Wagenen28 who had attempted a similar procedure at about the same time but had discontinued it. Serious complications had resulted when the intervertebral graft had worked loose and herniated posteriorly into the spinal canal, compressing the cauda equina. The following year (1944) Briggs and Milligan3 reported having packed the intervertebral space with bone chips in an effort to obtain an intracorpus fusion. These authors also recommended driving a round peg of bone into the interspace for stability. In 1945 Owens and Williams20 reported a similar procedure. The first report of my operative experiences was presented in 1945.5

Anterior spinal fusion, i.e., fusion of the vertebral bodies, has long been considered the best method of stabilizing the spine because of its mechanical efficiency. In an effort to overcome the unsatisfactory results of posterior fusion, orthopedic surgeons (Speed,26 Mercer16) have in the past made attempts to devise a procedure whereby the bodies of the involved vertebrae, that is, the major weight-bearing part of the spine, could be fused. Capener,4 in a study based on 34 cases of spondylolisthesis, concluded that the ideal operation to obtain greater mechanical efficiency would be one fixing the body of the 5th lumbar vertebra to the sacrum. He pointed out, however, that the technical difficulties of such a procedure precluded its trial.

The operation of vertebral body fusion devised by the writer consists of a subtotal removal of the intervertebral disc, including the cartilaginous plates, through a partial bilateral laminectomy. The cortical surfaces of the vertebral bodies are removed with a chisel and three or more large full-thickness bone grafts obtained from the iliac crest are driven forcibly into the interspace.

A series of 262 patients followed from 6 months to 8 years postoperatively
was reviewed in 1951 in preparation for a scientific exhibit at a meeting of the American Medical Association. A complete statistical review of these cases will be the subject of another communication. Although the material has been presented on several occasions, it has not been published. It seemed desirable to follow these cases over a long period of time and to accumulate a large enough series to be certain of my contention that this procedure is logical, practical, and has many advantages over other forms of treatment of ruptured lumbar intervertebral disc.

The number of complete and permanent cures obtained by the vertebral body fusion operation are 30 to 50 per cent higher than the "cures" after simple removal of the disc. This is attributed to the fact that vertebral body fusion eliminates the complaint of low-back pain which is the most frequent disabling postoperative symptom following simple disc removal.

INDICATIONS

The indications for spinal fusion in cases of ruptured lumbar intervertebral discs have been the subject of numerous articles in the medical literature, most of which have been written in an effort to determine which patient should be subjected to a spinal fusion and which one would get along on just a simple removal of the herniated portion of the disc. Even with our present diagnostic methods, no one has, as yet, been able to lay down specific criteria. It is true that many patients apparently remain asymptomatic for a long time following a simple disc removal. But others with exactly the same clinical picture may continue to have incapacitating low-back pain and/or develop a recurrence of the sciatica within a short time after the operation. Because of this difficulty in determining which operation a given individual may require, I have made my treatment uniform for every patient. Based on the thesis, "once a ruptured disc, always a ruptured disc," a vertebral body fusion has been done in practically every case of ruptured lumbar disc operated upon since 1944.

OPERATIVE TECHNIQUE

In the last 3 years I have received numerous requests from surgeons asking for a detailed description of the operative procedure. It is the purpose of this communication, therefore, in addition to giving the rationale of the procedure, to describe the operation as it is being done at the present time and to outline the postoperative care. The technique of vertebral body fusion from the posterior approach is not difficult for those familiar with the intervertebral disc operation and accustomed to working with the delicate structures of the nervous system in a small deep hole. By an experienced operator, the procedure can be carried out in 2 to 3 hours. At the present time, the writer performs the operation in 2 hours or less.

The procedure is actually three operations in one: removal of the bone grafts, laminectomy and removal of the intervertebral disc and lastly, the spinal fusion.
The bone grafts used for the fusion are obtained from the ilium, this being the ideal bone for this type of fusion. Before 1946, the bone grafts were removed from the patient’s own ilium. In the latter part of 1946, experiments with banked bone were begun and since 1947, cadaver bone, preserved by refrigeration, has been used for the operation whenever it was available. The use of banked bone shortens the procedure considerably and it is appreciated by the patient because he has only one wound to heal. The technique of banked bone has been reported elsewhere. To date, (September, 1952) 131 patients have been operated upon using banked bone.

The anesthetic used is intravenous pentothal sodium and 1 per cent novocain infiltrated into the skin and lumbar muscles. The patient is placed in the prone position with the spine sharply flexed and the knees bent at right angles, so that he is virtually kneeling on the table. Care must be
Fig. 2. Technique of vertebral body fusion. Note wide exposure of spinal canal by removal of half of articular facets. Upper right drawing shows only gelfoam covering dura mater. The ligamentum flavum is preserved to protect dura mater.

taken not to permit pressure upon the abdomen. This causes venous engorgement, stasis and increased bleeding from the epidural veins. The patient is placed upon a sponge mattress, cut to fit the operating table. The mattress is 4 inches in thickness, with a large hole in the center. The patient's abdomen is placed over this hole. The patient is routinely given 1, sometimes 2 pints, of whole blood during the procedure.

I. THE BONE GRAFTS

A 10-cm. curved incision is made parallel to the crest of the ilium and lateral to the posterior superior spine. The sacral attachments of the gluteal muscles are cut along the crest. Care must be taken not to injure the cluneal nerves which cross the iliac crest at this point. Patients have complained bitterly of postoperative pain in the iliac incision when these
nerves have been inadvertently divided or traumatized. The muscles on the anterior and posterior surfaces of the ilium are then stripped subperiosteally with a sharp osteotome. Two bone plugs, the full thickness of the ilium, are removed. These measure 1½ by 3 cm. and are cut out at right angles to the iliac crest. If the patient has a thick ilium, another plug may be obtained, removing the cancellous bone and the posterior cortical surface, and leaving the inner cortical surface of the ilium intact. A quantity of bone chips are removed medially with the gouge and curette. Bone wax is used to arrest the bleeding from the bone surface and the soft tissues are closed with chromic gut and black silk (Fig. 2).

II. THE LAMINECTOMY

The disc operation is done through an incision and exposure for laminectomy. The spinous processes and laminae of the vertebra above and below the level of the pathology are exposed and cleaned of all soft tissue. If the pathological disc is between L4 and 5, L3, 4 and 5 and S1 are exposed bilaterally and the edges of the adjacent laminae and spinous processes of L4 and 5 are removed. Only a deep notch is made in these structures; no complete laminectomy is performed. An excellent exposure of the intervertebral space can be obtained with a minimal amount of bone removal by the use of a special instrument devised for this purpose. This instrument, called the vertebra spreader11 (Fig. 3b and c), is a self-retaining retractor inserted between the spinous processes in the midline. The interspace can often be separated nearly twice its normal width and held in position throughout the procedure. With the vertebra spreader in place, the interlaminar ligaments are put on a stretch, and the attachments of the ligamentum flavum at the laminae and facets can be easily separated by touching them with a scalpel. An effort is made to preserve the entire ligamentum flavum, leaving it attached to the spinous process in the midline but cutting it free from the laminae above and below and from the articular facet laterally. The lateral half of the spinal canal is exposed by retracting the ligamentum flavum toward the midline like a hinge. It is held in this position by a heavy silk or catgut suture to which a hemostat is applied. This is repeated on both sides of the midline.

The interlaminar bony opening into the spinal canal is an important step in the procedure. A deep notch is made in the adjacent laminae, using a rongeur and a 5 mm. chisel. The exposure is carried as far lateral as the pedicle of the vertebra, removing half or more than half of the two articular facets (Fig. 1). The opening into the spinal canal is thus made as wide as possible. A greater exposure of the intervertebral disc is obtained and much less retraction upon the dural sac and nerve root is required for removal of the disc.

A second very useful instrument devised for this operation, the self-retaining dura retractor9 (Fig. 3a), is then inserted. This instrument, which can be attached to any laminectomy retractor, consists of a spatula which
is engaged beneath the nerve root and dura. These structures are retracted medially to the desired position and are held in place by the turn of a screw. This permits the surgeon to use both hands to perform the operation anterior to the spinal canal. This instrument eliminates the manual retracting, pulling and hauling on the nerve root and dura and protects these structures from any injury that may possibly occur during removal of the disc and insertion of the bone grafts.

When the dura mater is first exposed by retracting the ligamentum flavum, the epidural fat is gently separated from the dura mater near the midline. The self-retaining spatula is then inserted in this line of cleavage and the dura retracted medially. The epidural fat containing all of the large epidural veins then lies laterally in the spinal canal, separated from the dura and nerve root. Careful methodical cauterization of these vessels and removal of the epidural fat can be carried out with very little, if any, hemorrhage and the entire anterior wall of the spinal canal over the intervertebral disc is thus exposed, clean and dry.

A long-handled scalpel with a No. 11 pointed blade is used to remove a square plug from the posterior half of the annulus fibrosus of the disc. The knife blade is inserted to its maximum depth at the edge of the vertebral bodies and cuts are made transversely above and below the disc, medially under the dural sac, and laterally, as far as the exposure will permit, usually at or beyond the pedicle. With a strong end-biting (pituitary) disc rongeur a large plug of the disc, measuring 1×1×2 cm., is withdrawn in one piece.
This opening into the intervertebral space permits the removal of the soft parts of the disc under direct vision. A long slightly curved chisel, 7 mm. in width, is inserted beneath the cartilaginous plate and this structure is stripped easily from the vertebral body on either side of the interspace. With a sharp angulated curette and the disc rongeur, almost the entire disc is removed, leaving the adjacent surfaces of the vertebra completely clean of all soft tissue. This part of the procedure is bloodless.

It is advisable to remove with a chisel 3 to 5 mm. of bone from the superior edge of the lower vertebra. There is always an overhanging lip on the posterosuperior margin of the vertebral body. Removal of this ledge of bone makes it possible to visualize the entire superior surface of the vertebral body which may otherwise be obscured. This bone removal, which is also carried laterally to include part of the base of the vertebral pedicle, increases the width of the intervertebral space. This makes possible complete removal of all soft tissue under direct vision and aids in the insertion of the bone wedges. If marginal osteophytes are found along the rim of the upper vertebral body projecting into the spinal canal, these likewise are removed with the chisel, making sure their removal, bilaterally, extends well out into the intervertebral foramina laterally and beneath the dural sac medially. The cortical surfaces of the vertebral bodies are then chiseled off and the chisel is driven back into cancellous bone in numerous places. This assures a large, rough surface of raw bleeding cancellous bone in preparation for the bone grafts.

The dura retractor may then be removed and re-inserted on the opposite side of the spinal canal and a similar procedure carried out, removing the other half of the intervertebral disc. Or, the bone grafts may be inserted into the interspace on one side of the disc before the other half is removed. As much of the disc as possible is taken out, extending the removal to as near the anterior longitudinal ligament as possible. There is no danger of perforating the latter structures. With the vertebra spreader, one is able to see exactly how far anteriorly the disc removal is being extended. Also by forcing the spinous processes as wide apart as possible with the spreader, the anterior edges of the vertebral bodies are brought closer together.

III. THE FUSION

The bone plugs are shaped with the rongeur so that one end is slightly tapered. The pointed end is inserted into the opening in the intervertebral space, the iliac crest portion of the graft being posterior and the cancellous surface of the graft in contact with the raw surfaces of the vertebral bodies. The bone plug is then driven into the interspace with a large punch and a hammer. The self-retaining dura retractor acts as a shoehorn to protect the dural sac and the nerve root. The plug is fashioned so that, with the vertebra spreader in place, it is slightly larger in width than the intervertebral opening. By using force to drive these slightly larger plugs into position, the vertebrae are thus spread farther apart. The plug is driven about
\[ \frac{1}{4} \text{ to } \frac{3}{4} \text{ cm. beyond the posterior edge of the vertebral body, a notch having been made previously in this location when the cortical surfaces of the vertebra were removed. This small notch in the vertebral bodies and the countercutting of the plug obviates the danger of the grafts herniating posteriorly.}

As many bone wedges as possible are driven into the interspace. After the first one is inserted, the interspace is widened a little more with the handle of the vertebra spreader (Fig. 3c) and, with a wide (1 cm.) chisel inserted into the interspace lateral to the first plug, the latter is gradually worked toward the midline by twisting the chisel, using the pedicle as a fulcrum, until the graft comes to lie beneath the dural sac. An opening is thus made lateral to the first graft for the insertion of a second graft or even a third if the space will permit. The same procedure is carried out on the opposite side of the dural sac so that three or four plugs or more are inserted (Fig. 4). Oozing of blood from the raw cancellous bone of the vertebral bodies after removing the cortical surfaces may be encountered. After the bone plugs have been driven into place and the vertebra spreader has been removed, this bleeding is usually completely arrested. The danger of a latent complication of bony proliferation into the spinal canal from the bone grafts is not a problem since the hard cortical surface of the crest of the ilium is in contact with the dural sac forming the anterior wall of the spinal canal.

Gelfoam is placed over the nerve roots laterally and the ligamentum flavum is returned to its original position, completely covering the dural sac and nerve roots. The remaining half of the two adjacent laminae and facets are chiseled up with a small gouge and fine bone chips or crumbs are placed over the interlaminar opening, thus effecting a bony closure of the spinal canal posteriorly. The wound is closed using No. 0 chromic catgut and silk.

A single rubber tissue drain is left in the wound to run off any blood or serum that may accumulate in the first 24 hours. It is then removed. A drain has been used in every case. This is contrary to the practices of many surgeons who advocate closing a spinal fusion tightly without drains. We
have observed that a large quantity of blood and serum will often escape via the drain from the wound after a spinal fusion. Patients have soaked their sheets from knee to neck. It has been my belief that this drainage from raw bleeding bony surfaces, if not permitted to escape, would accumulate in the wound and diffuse through the lumbar muscles. This could be another contributing factor to the pain and stiffness of the back so frequently noted after a posterior spinal fusion.

**POSTOPERATIVE CARE AND RESULTS**

The patient is placed in bed supine on two mattresses with boards on the bed springs. The writer uses a sponge rubber mattress on top of the regular mattress. Some patients may have difficulty in voiding after operation. This probably results from retraction of the sacral nerve roots during the operation or possibly may be because of the patient's position in bed (flat on his back). If he is unable to urinate voluntarily within 8 hours after surgery, a Foley catheter is inserted. After the 2nd day, he is permitted to turn himself from side to side as he desires. On the 4th postoperative day, the patient is given a mild cathartic and an enema, and the catheter is removed. Sutures are removed from the wound on the 6th day. The patient is permitted out of bed within a week after the operation and is usually discharged from the hospital on or about the 10th postoperative day.

The patients operated upon by this procedure during the first 5 years were fitted with a low-lumbar back brace which was worn for 3 months. X-rays of the spine at the end of this time usually showed a solid bridge of bone between the bodies of the vertebrae. The brace was then discontinued and the patient was encouraged to exercise his back muscles. In the past 2 years, with more extensive grafting of the interspace, we have found it unnecessary to require the patient to wear a back brace. At operation, if the stability of the intervertebral joint is tested after the bone plugs have been driven into place, the joint will be found almost completely immovable. When the patient assumes the upright position and bears weight on the joint, the grafts are locked even tighter together, thus effecting a mechanical fixation of the intervertebral joint from the beginning. Since the back brace has been discontinued, patients seem to recover the normal flexibility of their spine much sooner. Being permitted to use their back muscles from the outset, there is no danger of stiffness of these muscles from shortening due to inactivity. Early ambulation has made no difference in the rate of fusion of the vertebral bodies; if anything the fusion takes place faster. If the patient's occupation requires him to do heavy work including bending and lifting, he is permitted to return to this type of work in approximately 3 months, depending on the appearance of the fusion as determined by x-rays (Fig. 5). Many patients return to heavy work before 3 months. The patient who is not required to do heavy manual labor is often able to return to his job within 2 weeks after the operation. In this day of high cost of hospital care, the short period of hospitalization
as well as the short period of convalescence before returning to work is extremely important to the patient, economically.

The most gratifying group of patients treated by this operation has been that of the industrial accident and insurance cases. It is the experience of all surgeons who do disc surgery in industrial cases to expect long periods of postoperative convalescence with the patient drawing compensation. If and when the case is closed, there is usually a fairly large settlement for permanent partial disability. My experience with the vertebral body fusion in compensation cases has been much more gratifying. In a series of 60 compensation cases, the average length of disability, that is, working days lost, was 169 days (5 1/2 months) from the initial lay-off until the patient had recovered from the operation and returned to work. This included the early cases when the operation was not perfected as it is today. In only 5 patients was it necessary to award a permanent disability. A complete discussion of this group will be presented in another communication.

With fusion of only one vertebral joint there is little if any limitation of movement of the lumbar spine and no pain. The patient is often aware of the loss of his vertebral pain the first time he assumes the vertical position after the operation. This “vertebral” pain, which the patient will
describe as a feeling of insecurity in the lower lumbar spine, is apparently
caused by loss of the support (nucleus pulposus) between two vertebrae. 
When this support (bone grafts) is re-established the pain immediately
disappears, even before a solid fusion, i.e. bridging of the intervertebral
graft, takes place.

The fusion between the vertebral bodies takes place rapidly and becomes
solid in a very short time. Within 2 to 3 months the grafts can be shown by
x-ray to have increased in density. This rapid fusion is aided by the fact
that the grafts are placed at right angles to the vertical axis of the spine
rather than parallel to it as is done in the Hibbs type of fusion. The possi-
bility of a pseudo-arthritis developing with the vertebral body fusion is
unlikely because the fusion takes place along the weight-bearing axis of the
spine. This line (through the nucleus pulposus) is the fulcrum of movement
of one vertebra articulating upon another. With forward, backward and
lateral action of the spine, movement is minimal at this point, and the
farther from this weight-bearing center the greater the separation of the
intervertebral spaces. It seems logical to assume that fusion at this point
of least movement has much less chance of failure than one done at a dis-
tance from it, namely, the spinous processes and laminae. My experience
with vertebral body fusion verifies these assumptions. A failure of fusion,
demonstrable by x-rays, has occurred in only 6 patients.

COMPLICATIONS

In the 6 cases in which there was failure of fusion, absorption of the
intervertebral grafts had occurred (unexplained), so they could not be recog-
nized by x-ray 3 to 4 months after surgery. In 2 patients after prolonged
convalescence, the vertebral bodies settled down and eventually fused.
The other 4 patients continued to complain of back pain until a second
fusion was performed. The experience of Van Wagenen of having the bone
plugs work loose and herniate into the spinal canal has occurred in only 1
case in my series. This patient had severe sciatica postoperatively and a
foot drop developed, which cleared up when the cause of the trouble was
demonstrated by x-ray and adjusted by reoperation. This complication
can be prevented if all cartilage and cortex are removed from the vertebral
bodies before the grafts are inserted. The graft will conceivably absorb,
decrease in size and work loose with movement of the spine if cartilage
prevents the graft from obtaining blood supply from the vertebral body.

It has been asked if the bone plugs ever herniate or telescope into the
 cancellous bone of the vertebral bodies. One might expect this to occur with
the hard cortical surfaces of the iliac graft in contact with what appears to
be soft cancellous bone in a major weight-bearing joint. The cancellous bone
of the lower lumbar vertebra, although appearing spongy, is apparently
as resistant and hard as the cortex of the graft, for this complication has
not occurred in my series. On the other hand, when a graft is used that is
composed only of cancellous bone, without the cortical surface of the iliac
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grafts, the graft is compressed with weight bearing and although an intervertebral fusion may occur, the normal width of the intervertebral space and foramen cannot be maintained as with the full-thickness iliac graft. This is of importance to assure complete success of the procedure.

Other complications have been encountered. Numbness of the foot and ankle with weakness of anterior tibial muscle have been occasionally noted. These symptoms are transient and usually disappear in days or weeks. One patient had a complete foot drop from her first operation (done elsewhere). After a second operation with fusion, the paralysis continued for 22 months, then recovered completely. These symptoms are, therefore, not considered serious. In 2 patients (early cases) there developed evidence of arachnoiditis of the cauda equina with intractable leg pain. This was attributed to lipiodol sensitivity. Bilateral upper thoracic cordotomy had to be resorted to for relief. Wound infections have been no higher than one would expect, considering the length of the operation and the use of foreign material (bone) in the wound. Infection is minimized by routine use of antibiotic drugs postoperatively. Of the 14 cases in which infection occurred it was necessary to remove the bone grafts in only 2. In all the others the wounds healed without loss of bone and went on to a more solid fusion than those that were not infected.

SUMMARY AND CONCLUSIONS

A detailed description of the operative technique for fusion of the vertebral bodies after removal of a ruptured lumbar intervertebral disc is presented. The rationale of such a procedure based on the anatomical physiology of the disc is discussed. The author’s experience with this operation in a large series of cases (321 to the present time) followed over a period of 8 years is described, including improvements in technique. The after care as well as complications that have been encountered are discussed. The rapidity with which patients recover from this operation and the high percentage of complete long-term cures (over 85 per cent) seem to justify the conclusion that this operation is the treatment of choice in the care of the patient with a ruptured lumbar intervertebral disc.

REFERENCES


28. VAN WAGENEN, W. P. Personal communication.