CHAPTER 45

Instrumented Transperitoneal Laparoscopic Fusion

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The usefulness of endoscopic techniques in peripheral joint and in general, urologic, thoracic, and gynecologic surgery is well established. In the areas where they have been successfully applied, significant improvements have been made in cost, length of hospital stay, patient suffering and cosmetic appearance. The historical background and technical aspects of the BAK^TM^ implant are discussed elsewhere in this book (Chapter 43). The first reported laparoscopic lumbar discectomy was done by Obenchain in 1991. He and D. Cloyd reported a series of their first 21 cases in 1994. Stein developed a midline laparoscopic approach for discectomy. Hallet Mathews and associates reported a series of five patients who received uninstrumented laparoscopic anterior fusion and were followed for 6 months. Sachs and Schwitzeberg reported their animal laboratory experience and two cases in humans with uninstrumented laparoscopic fusions at L5-S1. Novotney and associates had experience with eight noninstrumented laparoscopic fusions. In 1991, the principal authors received a research grant to develop an effective percutaneous fusion technique for the lumbar spine. Because of the emerging technology—bone morphogenic protein, laser technology, and advances in endoscopic surgery—it seemed that such a procedure was feasible and that the impediments presented by the tiny incisions used in endoscopic surgery could be overcome by new advances. Shortly after beginning our animal trials fusion cages were developed and were soon released for FDA human clinical trials. A round implant that conferred immediate stability to the motion segment to be fused was ideal for the percutaneous fusion approach. Using the BAK device and developing instrumentation to deliver it laparoscopically, we were able to routinely perform the procedure in the pig model after 2 years in development. From our experience with pedicle systems and anteroposterior fusions our goal was a relatively less traumatic approach that would deliver fusion rates as high as anteroposterior fusions with pedicle fixation. To date, we have performed 23 cases. There has been a significant learning curve. Although our follow-up is short, it is our impression that this technique has advantages over other equivalently successful fusion techniques. We therefore prefer this fusion technique to treat lumbar degenerative disc disease without translational deformity. Patient discomfort, hospital stay, and wound size are minimized once the operation is mastered.

METHODS

Technique

Preoperatively, patients undergo routine mechanical preparation of the large bowel to evacuate the sigmoid colon, which greatly aids the exposure of the lumbosacral spine. After administration of a general anesthetic and intubation a Foley catheter and nasogastric tube are placed. Arterial and central venous pressure lines are considered because of the Trendelenburg positioning of the patient. If lumbar extension is desired a 6×8-inch roll is placed under the lumbar spine. The knees are flexed 20°, or the feet may be anchored to the end of the table to maintain position during Trendelenburg’s positioning. Minimal equipment requirements are as follows:

Anteroposterior and lateral fluoroscope
Insufflator system
Endoscope—we use a 30° endoscope
Light source
One or two color monitors
VCR
Laparoscopic trocars
Laparoscopic adapters
Laparoscopic retractors
Insufflator needle
Coagulation unit—we use bipolar and monopolar
Standard laparoscopic instruments—graspers, pituitary, pledgets, and so on
Curettes
Laparoscopic delivery system for interbody implant (Fig. 45-1)

Autologous bone graft is harvested from the posterior or anterior iliac crest for packing in the titanium implants. Harvesting anterior grafts is advantageous because it can be done simultaneously with the abdominal exposure, thereby saving operative time. Currently, we use anterior graft for single-level cases and posterior graft for two-level cases.

A 2-mm incision is made at the umbilicus, and the insufflator needle is inserted in the abdominal cavity, which is insufflated, to a pressure of approximately 15 mm Hg. The endoscope 10-mm port is placed 5–10 cm cephalad of the umbilicus in the midline. The abdomen is inspected endoscopically, and the patient is placed in Trendelenburg’s position to allow the bowel to fall out of the pelvis and lower abdomen. Under endoscopic visualization two 10-mm working ports are placed just lateral to the epigastric vessels opposite the level or levels to be fused (Fig. 45-2). It is advantageous to stagger these two ports so they are not directly opposite each other. Retractors are then inserted, and the small...
bowel is swept cephalad out of the pelvis. The sigmoid colon is also pulled out of the pelvis and held laterally with the left fan retractor. For L5-S1 fusion, the sacral promontory and drop-off can be easily seen at this point. The posterior peritoneum overlying the L5-S1 disc space is then incised longitudinally with endo-shears for the desired exposure. Using opposing fan retractors as blunt dissectors, the surgeon sweeps the soft tissue underlying the posterior peritoneum laterally on both sides to expose the anterior annulus. The sacral artery and vein coursing over the midportion of the disc can be visualized. These vessels are ligated with hemoclips and transected. Residual soft tissue is removed with a Kittner dissector. The left fan retractor holds the colon out of the way; usually the right side does not require retraction, so a suction irrigator catheter is used in this port. If needed, an additional working port can be placed midline for suction irrigation in the site for the subsequent operating trocar incision. The lumbar sympathetic nerves should be protected using gentle blunt dissection and bipolar or no cautery. Dissection of the adventitial tissue anterior to the left common iliac vein and artery should be avoided.

At the L4-5 level the parietal peritoneum is incised about 4 cm above the sacral drop-off. The colon is retracted similarly to the L5-S1 approach. The bifurcation of the aorta is exposed by blunt dissection on its anterior aspect. The L4-5 disc is usually directly posterior to this. Left lateral dissection over the left common iliac vein and artery is performed, gently retracting these vessels to the right. The ascending segmental vein branch at L5 must be identified and ligated to mobilize the vessels over the L4-5 disc to the right. If the spine is hyperextended at this point, it may be flattened to diminish the tension on the great vessel to facilitate mobilization. The vessels are retracted to the right of the disc with a fan or loop retractor.

When the disc is exposed a skin incision is appropriately placed to make the operating trocar parallel to the end-plates. The skin entry point can be verified by placement of a Steinmann pin using lateral fluoroscopy. A 1.5–2.5-cm incision is made for the operating trocar, which is then placed intraabdominally over
with an 8-mm starting drill in the right or left entrance point. Sequential spacers from 9-14 mm are placed into the disc to distract it. A tight fit should be obtained (Fig. 45-6). The implant should be 3 mm larger than the spacer necessary to obtain a tight fit. The opposite entry point is then approached by centering the operating trocar over the disc and the end-plates and impacting it via the retractable teeth into the vertebra on either side of the disk. A centering rod with varying sized tips fits into the anterior disc and into the operating trocar to find the critical center point. The reaming and tapping, with sequential reamers is then carried out under lateral fluoroscopy to ensure appropriate depth (Figs. 45-4 and 45-8). The coronal position is also verified by anteroposterior fluoroscopy. The cage implant is packed with bone graft in its posterior chamber and screwed into the interspace through the operating trocar (Figs. 45-9 A and B). The opposite side spacer is removed and in similar fashion another cage is inserted on the side after reaming and tapping. Although there is often room for variations of implant position within the interspace, ideally, it should be recessed from both the anterior and posterior margin of the disc (Fig. 45-10). There is no advantage to placing the posterior border of the cage flush with the posterior vertebral cortex. In fact, this predisposes to migration of the end-plate and disc material into the spinal canal. If the x-ray unit is not aligned perpendicular to the patient, an image distorting the depth of the implant may result (Fig. 45-11). The anterior chambers of both cages are then packed.

FIG. 45-8. Intervertebral tapping.

the blunt introducer (Fig. 45-3). A two-pronged marking device is banked against the annulus to mark the right and left entrance points for the fusion cages. The central disc material is removed with curettes and rongeurs (Figs. 45-4 and 45-5). The disk is broached
with bone graft using the bone packing rod (Fig. 45-12).

Trendelenburg’s position is then reduced, and the abdominal cavity is inspected for bleeding under lower abdominal pressure. The retroperitoneum and incision sites are closed. Ambulation is begun when tolerated. We use a body jacket orthosis for 3 months after surgery (Fig. 45-13).

RESULTS

At the time of this writing, 34 fusion levels in 23 cases had been performed over a period of 14 months. Ten of the patients were male, and 13 were female. Ages ranged from 28 to 57, with a mean of 36. Twelve single-level fusions were performed, and 11 L4-S1 fusions were done. Twelve L4-5 level fusions were performed, and 21 L5-S1 level fusions. All patients had the diagnosis of painful degenerative disc disease with or without herniations. All patients had back pain greater than extremity pain. All patients had disabling symptoms for more than a year (averaging 3 years) and had not responded to elaborate nonsurgical treatment that lasted for at least 6 months. Average laparoscopic time for single-level was 3 h and ranged from 110 min to 6 h. For L4-S1 cases average laparoscopic operating time was 4.5 h, with a range of 7.25–3.75 h. Complications were two bone graft site infections, one upper GI bleed, one cage extrusion, one inferior vena cava laceration, one posterior end-plate fracture, one posterior
extrusions of the disc, one femoral artery thrombosis secondary to femoral arterial line placement, and three prolonged ileus. Most of the complications occurred in the L4–5 two-level cases. Two patients required conversion to open procedures: one due to vein laceration and one due to extensive adhesions from previous surgeries. Two patients required subsequent posterior decompression procedures and had partial L5 palsy, which subsequently improved. The complications were in large part due to inexperience with a new approach and a long learning curve starting from the inception of this operation. Postoperative stay ranged from 1 day to 21 days. In uncomplicated cases the average stay was 4.5 days. A preliminary clinical follow-up in the first 14 patients of 2–14 months (with an average of 7 months) shows:
excellent results in three, good in seven, fair in three, and poor in one based on patient responses to standardized questionnaires (Figs. 45-14 and 45-15).

DISCUSSION

This operation is the result of explosive advances in endoscopic techniques and equipment and the availability of the cylindrical fusion cage, which confers good stability to the fused segment and can easily be delivered endoscopically. We believe that the BAK device has advantages over pedicle-based instrumentation. The device immobilizes the vertebrae at the center of the motion segment and should more rigidly restrict the disc space when solid. Because this instrumentation is delivered anteriorly, there is no encroachment on adjacent levels, and the need to remove the hardware removal is considerably lessened. Unlike for pedicle systems, the rate of infection is quite low with the BAK device. Fatigue studies show the BAK performs favorably compared with pedicle fixation systems. In a biomechanical study Brodke and associates showed the initial stiffness of the BAK was equivalent to a single-level Texas Scottish Rite Hospital (TSRH) pedicle construct. When delivered laparoscopically the threaded-cage system provides minimal soft tissue destruction, good initial immobilization, and a rigid scaffolding that will not soften during the revascularization of the graft. It has replaced the instrumented 360° fusion in our practice and appears to be a much more elegant way to achieve equivalent results with less expense and fewer complications, once the technique is mastered.

The procedure is in its infancy and is improving on a weekly basis. The present instrumentation is the first revision, and many more improvements are on the way. Our impression now is that at least 20 cases are needed to master the basics of this procedure. The learning curve for those that follow us will certainly be shorter; nevertheless, the technique is extremely demanding and requires dependence on elaborate technically sophisticated equipment. It requires precise hand–eye coordination for video-assisted endoscopic surgery, as well as remote soft tissue and bone dissection skills. Familiarity with the open counterparts for this procedure, ability to manage vascular injuries, and complete familiarity with the retroperitoneal and visceral anatomy are essential prerequisites for the surgeons. Operating room personnel must also be familiar with endoscopic video-assisted techniques and laparoscopy.

CONCLUSION

This is a new fusion technique that appears to have advantages over other current approaches. Further refinement and study is necessary to find its rightful position in our fusion armamentarium. Although complications and their rate have been significant, this is in large part due to the learning curve in a brand new approach with prototype equipment. We only have short-term follow-up at this time; however, those investigators who have had extensive experience with all commonly used fusion techniques feel this technique is preferable to others, especially in light of the alternative fusion techniques that this procedure replaces. Cosmetic appearance, incisional discomfort, intraoperative blood loss, and postoperative spinal infection rate have improved remarkably with this technique, and long-term complications, such as those requiring removal of implants, are or are expected to be very low. Judging from open BAK results, fusion rate is expected to be high, and operative time is recently running one to two hours per level fused.

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REFERENCES

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