ENDOSCOPY OF THE LUMBAR SPINE

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ENDOSCOPY OF THE LUMBAR SPINE

Introduction

The usefulness of endoscopy is well established in peripheral joints, general, urological, thoracic and gynecological surgery. The successful implementation of endoscopic techniques has resulted in significant reductions in cost, length of hospital stay, patient suffering and cosmesis. (3, 21, 25) The main advantages of minimally invasive techniques include the following: (9-13)

1. avoidance of epidural bleeding and perineural fibrosis
2. elimination of reherniation in spinal canal through surgically induced annular fenestration
3. preservation of spinal stability due to lack of bony resection
4. establishment of a portal away from neural elements for future herniations
5. cost effective
6. does not compromise future surgery should it be necessary
7. cosmesis
8. diminished post-operative discomfort
Endoscopic anterior lumbar discectomy and fusion

Rationale and historical perspective

Relief of both back and leg pain through anterior fenestration of the annulus was first described by Hult in 1951. He postulated that pressure of a damaged disc could be diverted anteriorly rather than transmitted posteriorly by anterolateral annulotomy via an open retroperitoneal approach. (6)

In 1991, Obenchain (17) reported the first laparoscopic lumbar discectomy. Together with Cloyd (18), he subsequently reported the first series of 21 laparoscopic lumbar discectomies in 1994. Slotman and Stein (27) described a midline laparoscopic approach for discectomy in 1994. The same year, at the 9th annual North American Spine Society meeting, Matthews (15) and others (16, 24) reported their experience with uninstrumented laparoscopic fusions. Further, the senior author (28) has reported on laparoscopic lumbar fusions using anteriorly placed fusion cages.

Anatomy and technique of discectomy and instrumented lumbar fusion

Following routine mechanical large bowel prep to evacuate the sigmoid colon and aid in the exposure of the lumbosacral spine, the patient is placed in the supine position and general anesthesia is induced. A nasogastric tube and Foley catheter are then placed, as well as any additional cardiovascular monitors. The lumbar spine
is extended over a roll placed under the lumbar region. The entire abdomen is then prepped and draped in the usual fashion. \textit{(Figure 1)}

The insufflator needle is then inserted through a 2mm incision at the umbilicus. The abdominal cavity is then insufflated to a pressure of approximately 15mm of Hg. The endoscope portal is then established 5 to 10 cm cephalad to the umbilicus in the midline and the abdomen is inspected. The patient is then placed in Trendelenburg in order to allow the bowel to fall out of the pelvis and lower abdomen. \textit{(Figure 2)} Two 10mm working portals are then established under direct visualization just lateral to the epigastric vessels opposite the level or levels to be removed (and/or fused). Retractors are then inserted and employed to sweep the small bowel cephalad out of the pelvis. The sigmoid colon is swept laterally and held with a fan-type retractor.

At L5-S1, the promontory is readily visualized and the posterior peritoneum overlying the disc space is longitudinally incised with endoshears. The anterior annulus is then exposed by blunt dissection of the soft tissue underlying the posterior peritoneum using the fan retractors and the Kitner dissector. \textit{(Figure 3)} The sacral artery and vein course directly over the mid portion of the field. They are hemoclipped and transected. The left fan retractor remains in place holding back the colon, while the right one is replaced by a suction irrigator. Throughout, the lumbar sympathetics are protected by avoidance of dissection anterior to the left common iliac vein and artery and minimization of cauterization. \textit{(Figure 4)}
For the L4-5 level, the parietal peritoneum is longitudinally incised approximately 4 centimeters cephalad to the sacral promontory at the level of the bifurcation. If the vessel anatomy is normal, this usually marks the level of the L4-L5 disc. The left common iliac vein and artery are gently retracted to the right after left lateral dissection. Next, the left ascending segmental vein branch at L5 is identified and ligated in order to mobilize the vessels over the L4-5 disc space to the right. This vessel is typically hidden and must be sought caudal to the L4-5 disc and posterior to the vena cava. (Figures 5 and 6)

With the disc space exposed, a skin incision is placed so the operating trocar will be parallel to the end plates with the aid of the lateral fluoroscope and a Steinmann pin. With the operating trocar in the proper position, one may use either a 12 or 18mm trocar curettes and pituitary rongeurs, or a nucleotome to remove the central disk material. (Figures 7, 8, and 9)

For the allograft or autologous graft fusions, the interspace is then prepared for fusion by cutting of the end plates with Crock-type circular gouges (available from Shelton-Thompson), or other specialized instrumentation. The interspace should be hyperextended at this point in order to help lock in the bone plugs. (Figure 10) We use the Crock cookie cutter gouge and place it on the anterior surface of the vertebral bodies. The alignment is verified with the fluoroscope in order to assure equal cuts in the adjacent end plates.

We carry out instrumented laparoscopic anterior interbody
fusions with the BAK fusion cage by Spinetech. Pre-operative x-rays are used in order to estimate implant size. The BAK system has a starting point localizer with unipolar cautery in order to assure proper spacing of the cages. (Figure 11) The Spinetech trocars are made to fit the implant system, so these are then used for final preparation of the interspace. The Spinetech reamer is employed in order to fashion two circular holes of the proper depth, parallel to each other, and separated by approximately 4mm of space between them. A temporary spacer is used to distract the interspace while the first BAK cage is inserted under direct endoscopic visualization, with fluoroscopic verification of depth. (Figures 12 - 15) The spacer is then removed and the second cage is placed in similar fashion. The bone impactor tube is filled with bone graft and each anterior cage chamber is filled with morselized graft. (Figures 16 and 17) The ideal position of the cages is demonstrated in figures 18A and 18B.

Following completion of the discectomy and fusion, the Trendelenburg position is then reduced, and the abdominal cavity is thoroughly inspected for bleeding under lower abdominal pressure. Finally, the retroperitoneum and skin incisions are closed. (Figures 19 and 20) Ambulation in a body jacket is begun when tolerated. Plain AP and lateral and lateral flexion-extension x-rays are performed at follow up visits in order to evaluate fusion status. (Figures 21A and 21B) Single cut biplane sagittal flexion extension tomography has been most useful in detecting small amounts of motion at the fusion site.
Applied physiology and complications

The two most important areas of applied physiology which can potentially lead to laparoscopic complications are cardiovascular and pulmonary. The cardiovascular complications include tension pneumoperitoneum, cardiac dysrhythmia, venous stasis/thrombosis, hypothermia, and cerebral ischemia or edema. Additionally, the pulmonary complications are usually insufflation related and include hypercapnia, acute respiratory insufficiency, hypoxia, acidosis, extraperitoneal gas, gas embolism and explosion. The urologic and gynecologic literature is replete with reviews and surveys reporting the rates of laparoscopic complications of 0.6 to 2.4% with mortality rates in the range of 0.004 to 0.18%. Some one third of these complications are physiological in nature.

The cardiovascular system must deal with the mechanical effects of pneumoperitoneum, the hemodynamic stimulation of absorbed carbon dioxide, and the volume shifts brought about by positioning. Increases in central venous pressure and venous resistance are counteracted by a stimulatory effect of carbon dioxide resulting in a net minimally altered cardiac pre-load at, or below, the recommended intra-abdominal pressure limit of 15 to 20mm Hg. Analysis of cardiac performance shows an increased heart rate offsetting a slightly decreased stroke volume yielding a minimally altered cardiac output. Finally, arterial pressure and arterial resistance are increased during laparoscopy resulting in an increased after-load.
While healthy individuals easily tolerate the somewhat hyperdynamic state induced by laparoscopy, one must exercise caution when performing surgery on those with cardiac disease. In particular, some have considered cardiomyopathy, untreated congestive heart failure, and moderate to severe ischemic heart disease as contraindications to laparoscopic procedures. Once the intra-abdominal pressure exceeds 40 mm Hg., the compensatory mechanisms begin to fail. Blood flow becomes much more severely restricted and positional influences much more significant. "Tension pneumoperitoneum" results in precipitous drops in venous return, cardiac output, and blood pressure. Cardiac dysrhythmias have been linked to hypercapnia and vagal stimulation secondary to peritoneal irritation. Increased intra-abdominal pressures can also lead to venous stasis through restriction of venous return.

Carbon dioxide is the most commonly used insufflant in laparoscopy. It is, however, also absorbed by the tissues of the peritoneum. The absorption of carbon dioxide causes a mild respiratory acidosis. Additionally, increased intra-abdominal pressure restricts diaphragmatic motion and respiratory capacity. In healthy individuals, the increased levels of arterial carbon dioxide are easily managed by increased ventilation. This may not be possible in patients with underlying pulmonary disease. Mild hypercapnia has a stimulatory effect; however, once arterial levels exceed 60 mm Hg., direct cardiac depression results. Further, extraperitoneal gas may dissect along tissue planes and
blood vessels into the pleural space, mediastinum, pericardium or retroperitoneum. Venous gas embolism results from direct injection of gas into the venous system during insufflation and can be fatal. Intra-abdominal explosion has rarely been reported during the use of both oxygen and nitrous oxide for insufflation.

In a recent prospective, multicenter study, McAfee, et. al. reported two bone graft donor site infections and one left common iliac vein injury as the only complications in a series of 22 laparoscopic instrumented fusion procedures. There were no reported complications from pneumoperitoneum or CO2 insufflation. The senior author's experience has included two patients who required a subsequent posterior decompression for a displaced end plate fracture behind the cage.

Finally, while the application of laparoscopic surgical techniques is exciting, it is not without its own physiological burdens. Knowledge and awareness of the underlying pathophysiology of laparoscopy aids in the prevention, diagnosis, and treatment of its complications. The procedure is extremely demanding and requires reliance on elaborate, sophisticated equipment. Familiarity with the open counterpart of this procedure, ability to manage vascular injuries, and thorough facility with the retroperitoneal and visceral anatomy are absolute prerequisites for this procedure.
STEPS FOR LAPAROSCOPIC DISCECTOMY

* 1) COLON PREP:
   a) NPO
   b) Go-litely 3 liters night before surgery
   c) Fleets enema night before the surgery

* 2) PRE-OP:
   a) Foley catheter
   b) CVP and arterial lines
   c) Kidney rest or sandbag or extension of hips if lumbar extension is desired.
   d) TED hose and compression boots

* 3) C-ARM AND APPROACH SET UP:
   a) AP and lateral
   b) Prior to draping mark skins incisions with marking pen along correct trajectory (parallel to the end plates) for the operating trocars to enter the discs to be fused utilizing the c-arm lateral image

* 4) PREP AND DRAPE

* 5) ESTABLISH PNEUMOPERITONEUM:
   a) Vares type needle - enter perpendicular to and at umbilicus. If previous surgical incision avoid the
area of expected abdominal adhesions

b) Check insufflator and insufflate to 15mm approximately
c) After insufflation attained may start 500mg of Xylocaine in 500cc drip - may or may not be helpful

* 6) ATTACH SUCTION IRRIGATION APPARATUS, UNIPOLAR AND/OR BIPOLAR CAUTERY, LAPAROSCOPE LIGHT SOURCE, DEFOGGER

* 7) PLACE PATIENT IN STEEP TREDELENGBERG

* 8) PLACEMENT OF LAPAROSCOPE TROCAR, OPTICAL TROCAR ENABLES VISUALIZATION DURING INSERTION

* 9) INSERTION OF TWO FAN RETRACTORS AND THEIR TROCARS (10-12mm) OPPOSITE THE OPERATIVE SITE DURING DIRECT VISUALIZATION BY LAPAROSCOPE TO AVOID INJURY TO THE EPIGASTRIC VESSELS. THE RIGHT SIDE PORT IS USUALLY USED LATER FOR SUCTION, SCISSORS, CAUTERY AND PEANUT SO HAVE 5mm ADAPTORS READY...

* 10) LYSE ANY ADHESIONS BLOCKING VISUALIZATION OF THE SPINE

* 11) MOBILIZE COLON TO LEFT, HOLD WITH FAN RETRACTOR

* 12) RETRO-PERITONEAL DISSECTION
NO CAUTERY IN MALES, ENTER RETROPERITONEUM FROM RIGHT SIDE, LOOK FOR SYMPATHETICS, AVOID THE ANTERIOR SURFACE OF
13) IDENTIFY DISC, PLACE STEINMAN PIN IN DISC IN MIDLINE.
CHECK AP AND LATERAL IMAGE

14) PLACE OPERATING TROCAR IN PROPER ALIGNMENT. PRESENTLY ONE
MAY CHOOSE A 12mm TROCAR TO EVACUATE DISC. WE USE
CURETTES TO EVACUATE DISC AND PITUITARY RONGEURS. A LARGE
NUCLEOTOME HAS BEEN DESIGNED FOR LAPAROSCOPIC DISCECTOMY.
CHECK DEPTH OF INSTRUMENTATION ON C-ARM WHENEVER ANY
QUESTION OF INTRADISCAL DEPTH.

15) LATERAL C-ARM IMAGING IS DONE TO ASSURE THE APPROACH OF
THE OPERATING TROCAR AND DISCECTOMY INSTRUMENTS ARE
PARALLEL TO THE END PLATES AND CENTERED ON THE INTERSPACE.
SOME MINOR ADJUSTMENTS ARE TYPICAL

16) THE PARIETAL PERITONEUM IS CLOSED AFTER INSPECTION WITH
LOWER INTRA-ABDOMINAL PRESSURE FOR BLEEDING

17) THE PORT WOUNDS ARE CLOSED INCLUDING THE FASCIA
STEPS FOR LAPAROSCOPIC FUSION WITHOUT INSTRUMENTATION

1) COLON PREP:
   a) NPO
   b) Go-litely 3 liters night before surgery
   c) Fleets enema night before the surgery
   d) TED hose and compression boots

2) PRE-OP:
   a) Foley catheter
   b) CVP and arterial lines
   c) Kidney rest or sandbag or extension of hips if lumbar extension is desired.

3) C-ARM AND APPROACH SET UP:
   a) AP and lateral
   b) Prior to draping mark skins incisions with marking pen along correct trajectory (parallel to the end plates) for the operating trocars to enter the discs to be fused utilizing the c-arm lateral image

4) PREP AND DRAPE

5) ESTABLISH PNEUMOPERITONEUM:
   a) Vares type needle - enter perpendicular to and at umbilicus. If previous surgical incision avoid the
area of expected abdominal adhesions
b) Check insufflator and insufflate to 15mm approximately
c) After insufflation attained may start 500mg of Xylocaine in 500cc drip - may or may not be helpful

* 6) MAY START ANTERIOR BONE GRAFT HARVESTING IF YOU ARE USING IT (BONE ALLOGRAFT DOWELS, FEMORAL RINGS PACKED WITH AUTOLOGOUS OR ALLOGRAFT CHIPS ARE SOME SOME ALTERNATIVE TECHNIQUES) BY ASSISTANT SURGEON WHILE OTHER(S) PLACE SCOPE AND SET UP REST OF INSTRUMENTATION.

* 7) ATTACH SUCTION IRRIGATION APPARATUS, UNIPOLAR AND/OR BIPOLAR CAUTERY, LAPAROSCOPE LIGHT SOURCE, DEFOGGER

* 8) PATIENT IS PLACED IN STEEP TRENDENBERG

* 9) PLACEMENT OF LAPAROSCOPIC TROCAR USUALLY 2-4"
SUPRAUMBILICAL, OPTICAL TROCAR ENABLES VISUALIZATION DURING INSERTION

* 10) INSERTION OF TWO FAN RETRACTORS AND THEIR TROCARS (10-12mm) OPPOSITE THE OPERATIVE SITE DURING DIRECT VISUALIZATION BY LAPAROSCOPE TO AVOID INJURY TO THE EPIGASTRIC VESSELS. THE RIGHT SIDE PORT IS USUALLY USED LATER FOR SUCTION, SCISSORS, CAUTERY, AND PEANUT, SO HAVE 5mm ADAPTORS READY...
* 11) LYSE ANY ADHESIONS BLOCKING VISUALIZATION OF THE SPINE

* 12) MOBILIZE COLON TO LEFT, HOLD WITH FAN RETRACTOR

* 13) RETROPERITONEAL DISSECTION

NO CAUTERY IN MALES, ENTER RETROPERITONEUM FROM RIGHT SIDE, LOOK FOR SYMPATHETICS, AVOID THE ANTERIOR SURFACE OF THE LEFT COMMON ILIAC VEIN AS MUCH AS POSSIBLE. HOOK CAUTERY, UNIPOLAR, BIPOLAR ENDO-SCISSORS, ENDO-SCISSORS, PEANUTS ARE AVAILABLE.

* 14) IDENTIFY DISC AND VERIFY APPROACH

PLACE STEINMAN PIN IN DISC IN MIDLINE, CHECK AP AND LATERAL WITH STEINMAN IN DISC. VERIFY THE ENTRANCE OF INCISION IS IN LINE AND PARALLEL WITH THE TWO END PLATES OF THE LEVELS TO BE FUSED.

* 15) FURTHER EXPOSURE OF DISK

USUALLY NOT NECESSARY AT L5-S1, BUT AT UPPER LEVELS DISSECTION AND MOBILIZATION OF THE GREAT VESSELS IS NECESSARY. A LOOP OR FAN RETRACTOR NEEDED ON THE RIGHT SIDE TO RETRACT THE VESSELS RIGHTWARD. AT L4-5, THE LEFT ASCENDING SEGMENTAL VEIN OVER THE BODY OF L5 MUST BE IDENTIFIED AND LIGATED TO GAIN ENOUGH EXPOSURE OF THE DISC FOR FUSION, BUT A SUBTOTAL DISCECTOMY MAY BE DONE WITHOUT LIGATING THE VEIN.
16) PLACE OPERATING TROCAR IN PROPER ALIGNMENT. PRESENTLY ONE MAY CHOOSE THE 12 OR 18mm ETHICON TROCAR TO EVACUATE DISC. WE USE CURETTES TO EVACUATE DISC AND PITUITARY RONGEURS. NUCLEOTOME MAY ALSO BE USED.

17) VERTEBRAL END PLATE CUTTING

WE HAVE USED CROCK-TYPE CIRCULAR GOUGES TO PREPARE THE INTERSPACE. THE END PLATES SHOULD BE CUT WITH THE INTERSPACE IN SOME LUMBAR EXTENSION TO HELP LOCK THE GRAFTS IN AND MAINTAIN LUMBAR LORDOSIS. PRE-CUT ALLOGRAFT DOWELS AND FEMORAL RINGS THAT MATCH THE CROCK INSTRUMENTATION CAN BE OBTAINED FROM TISSUE BANKS. WHEN THE CROCK-END PLATE COOKIE CUTTER IS BANKED AGAINST THE ANTERIOR VERTEBRAE LATERAL C-ARM IMAGING IS USED TO VERIFY EQUAL CUTS OF AND PARALLEL TO THE END PLATES.

18) BONE GRAFT MAY BE PLACED THROUGH A MINI INCISION OR THE 18mm OR 33mm TROCARS DEPENDING ON THE SPECIFIC TECHNIQUE CHOSEN

A GRAFT HOLDING DEVICE IS USEFUL TO INSERT THE GRAFT, OR GRAFTS, AND IMPACT. THEN REVERSE THE LUMBAR LORDOSIS AND TEST THE GRAFT STABILITY.
19) **THE PARIETAL PERITONEUM IS CLOSED AFTER INSPECTION WITH LOWER INTRA-ABDOMINAL PRESSURE FOR BLEEDING**

20) **THE PORT WOUNDS ARE CLOSED INCLUDING THE FASCIA**
STEPS FOR LAPAROSCOPIC BAK FUSION

* 1) COLON PREP:
   a) NPO
   b) Go-litely 3 liters night before surgery
   c) Fleets enema night before the surgery

* 2) PRE-OP:
   a) Foley catheter
   b) CVP and arterial lines
   c) Kidney rest or sandbag or extension of hips if lumbar extension is desired.

* 3) C-ARM AND APPROACH SET UP:
   a) AP and lateral
   b) Prior to draping mark skins incisions with marking pen along correct trajectory (parallel to the end plates) for the operating trocars to enter the discs to be fused utilizing the c-arm lateral image
   C) TED hose and compression boots

* 4) PREP AND DRAPE

* 5) ESTABLISH PNEUMOPERITONEUM:
   a) Vares type needle - enter perpendicular to and at umbilicus. If previous surgical incision avoid the
area of expected abdominal adhesions
b) Check insufflator and insufflate to 15mm approximately
c) After insufflation attained may start 500mg of Xylocaine in 500cc drip - may or may not be helpful

* 6) MAY START ANTERIOR BONE GRAFT HARVESTING BY ASSISTANT SURGEON WHILE OTHER(S) PLACE SCOPE AND ATTACH REST OF INSTRUMENTATION.

* 7) ATTACH SUCTION IRRIGATION APPARATUS, UNIPOLAR AND/OR BIPOLAR CAUTERY, LAPAROSCOPE LIGHT SOURCE, DEFOGGER

* 8) PLACE PATIENT IN STEEP TRENDELENBERG

* 9) PLACEMENT OF LAPAROSCOPIC TROCARS, OPTICAL TROCARS ENABLES VISUALIZATION DURING INSERTION

* 10) INSERTION OF TWO FAN RETRACTORS AND THEIR TROCARS (10-12mm) OPPOSITE THE OPERATIVE SITE DURING DIRECT VISUALIZATION BY LAPAROSCOPE TO AVOID INJURY TO THE EPIGASTRIC VESSELS. THE RIGHT SIDE PORT IS USUALLY USED LATER FOR SUCTION, SCISSORS, CAUTERY, AND PEANUT, SO HAVE 5mm ADAPTORS READY...

* 11) LYSE ANY ADHESIONS BLOCKING VISUALIZATION OF THE SPINE
12) MOBILIZE COLON TO LEFT, HOLD WITH FAN RETRACTOR

13) RETROPERITONEAL DISSECTION
   NO CAUTERY IN MALES, ENTER RETROPERITONEUM FROM RIGHT SIDE, LOOK FOR SYMPATHETICS, AVOID THE ANTERIOR SURFACE OF THE LEFT COMMON ILIAC VEIN AS MUCH AS POSSIBLE.

14) IDENTIFY DISC, PLACE STEINMAN PIN IN DISC IN MIDLINE, CHECK AP AND LATERAL WITH STEINMAN IN DISC. VERIFY ENTRANCE OF INCISION IS IN LINE AND PARALLEL WITH THE TWO END PLATES OF THE LEVELS TO BE FUSED

15) FURTHER EXPOSURE OF DISK
   USUALLY NOT NECESSARY AT L5-S1, BUT AT UPPER LEVELS DISSECTION AND MOBILIZATION OF THE GREAT VESSELS IS NECESSARY. A LOOP OR FAN RETRACTOR NEEDED ON THE RIGHT SIDE TO RETRACT THE VESSELS RIGHTWARD. AT L4-5, THE LEFT ASCENDING SEGMENTAL VEIN OVER THE BODY OF L5 MUST BE IDENTIFIED AND LIGATED TO GAIN ENOUGH EXPOSURE OF THE DISC FOR FUSION, BUT A SUBTOTAL DISCECTOMY MAY BE DONE WITHOUT LIGATING THE VEIN

16) PLACE OPERATING TROCAR IN PROPER ALIGNMENT. PRESENTLY, ONE MAY CHOOSE THE 18mm TROCAR TO EVACUATE DISC AND MOVE UP TO SPINETECH TROCAR FOR BAK INSTRUMENTED FUSION. WE USE CURETTES TO EVACUATE DISC AND PITUITARY RONGEURS.
ENTRANCE ANNULOTOMIES SHOULD BE EQUIDISTANT FROM THE ANTERIOR MIDLINE AND ALLOW ABOUT 4mm SPACE BETWEEN THE MEDIAL IMPLANT BORDERS AS THESE SITES WILL BE USED FOR LATER SPACER AND INTERBODY IMPLANT DISC ENTRY POINTS IN THE BAK FUSION. A SPINETECH STARTING POINT LOCALIZER WITH UNIPOLAR CAUTERY IS PROVIDED. THEY SHOULD EXTEND FROM ANTERIOR END PLATE TO ANTERIOR END PLATE IN THE SAGITTAL PLANE. FOR A NON-INSTRUMENTED FUSION, BONE GRAFT MAY BE PLACED THROUGH A MINI INCISION, OR THE 33mm TROCAR CAN BE PLACED

* 17) ESTIMATE IMPLANT SIZE BY PREOPERATIVE X-RAY AND TEMPLATES. WE BELIEVE THIS ESTIMATE SHOULD BE TAKEN WITH A GRAIN OF SALT. PLACE SPACER THROUGH HOLE (MADE FROM THE DISC EVACUATION SITES) IN DISC AND INCREASE THE SIZE OF SPACER UNTIL "LOCKED" IN INTERSPACE. GO > OR = TO 3mm HIGHER THAN SPACER SIZE FOR BAK IMPLANT SIZE. MAKE SURE YOU HAVE ENOUGH ROOM IN THE CORONAL PLANE FOR THE IMPLANTS BY REFERRING TO THE TEMPLATES AND PREOPERATIVE X-RAYS IF YOU HAVE NOT DONE THIS FOR THIS SIZE IMPLANT

* 18) REMOVE THE 18mm TROCAR AND REPLACE WITH THE SPINETECH TROCAR OF THE SIZE THAT FITS THE SELECTED IMPLANT SIZE. THE APPROPRIATE DEPTH CORRESPONDING TO THE IMPLANT CAGE SIZE IN BOTH DIAMETER AND LENGTH ESTIMATED FROM PRE-OP X-RAYS IS SELECTED FOR THE OPERATING TROCAR ASSEMBLY

20) LATERAL C-ARM IMAGING IS DONE TO ASSURE THE APPROACH OF THE OPERATING TROCAR IS PARALLEL TO THE END PLATES AND CENTERED ON THE INTERSPACE. SOME MINOR ADJUSTMENTS ARE TYPICAL.

21) HOLDING YOUR POSITION, THE BLUNT REAMER IS MOUNTED WITH THE SAME SIZED NIB TIP AND A FEW mm REAMED. TAKING CARE TO MAINTAIN THE SAME POSITION OF THE OPERATING TROCAR, THE SHARP REAMER IS USED TO COMPLETE THE REAMING. ALTHOUGH THE BAK INSTRUMENTATION IS DESIGNED WITH SAFEGUARDS TO MAKE IT DIFFICULT TO REAM TOO DEEPLY, ONE SHOULD NOT RELY ON THE INSTRUMENTATION ALONE; FREQUENT C-ARM IMAGES IN THE LATERAL PLANE SHOULD BE VIEWED TO ASSURE PROPER DEPTH.
NOT ATTEMPT TO PLACE THE CAGE IMPLANT FLUSH WITH THE
POSTERIOR VERTEBRAL CORTEX. AT LEAST 3mm SHOULD BE LEFT
TO PREVENT FRACTURE, POSTERIOR DISC EXTRUSION, TOO FAR
POSTERIOR POSITIONING OF THE IMPLANT OR SHARP REAMER.
AFTER REAMING IS COMPLETED, THE IMPLANT SITE IS TAPPED
WITH THE APPROPRIATE SIZE TAP

* 22) THE IMPLANT IS PACKED IN ITS POSTERIOR CHAMBER AS SOON AS
THE SIZE IS DECIDED UPON AND SCREWED INTO THE INTERSPACE
UNTIL THE APPROPRIATE DEPTH IS OBTAINED ON C-ARM IMAGING.
THE OPERATING TROCAR TEETH ARE RETRACTED AND SPACER IS
REMOVED ON THE OPPOSITE SIDE WITH THE SPACER ROD.

* 23) THE SAME SIZE NIB USED ON THE OTHER SIDE IS MOUNTED ON THE
BLUNT REAMER AND TWISTED INTO THE INTERSPACE WHERE THE
SPACER WAS REMOVED. THIS IS USED AS THE CENTERING ROD WAS
ON THE OPPOSITE SIDE, SAVING A STEP. THE OPERATING TROCAR
TEETH ARE PROTRACTED AND IMPACTED INTO THE VERTEBRA UNDER
VISUALIZATION. APPROACH TO THE INTERSPACE IS AGAIN
CHECKED BY LATERAL C-ARM VISUALIZATION.

* 24) THE SAME SEQUENCE OF STEPS IS TAKEN WITH THE SECOND CAGE
IMPLANT) AP AND LATERAL C-ARM IS TAKEN TO VERIFY
SATISFACTORY POSITION.

* 25) THE BONE IMPACTOR TUBE IS FILLED WITH BONE GRAFT AND EACH
ANTERIOR CAGE CHAMBER IS FILLED WITH MORSELIZED BONE
GRAFT.

* 26) THE PARIETAL PERITONEUM IS CLOSED AFTER INSPECTION WITH
LOWER INTRA-ABDOMINAL PRESSURE FOR BLEEDING

* 27) THE PORT WOUNDS ARE CLOSED INCLUDING THE FASCIA
Pitfalls in Laparoscopic Fusion

Although the technique seems straightforward, subtleties can cause more problems than open discectomies and fusions. Hopefully, our adventures will minimize yours.

* There is no good reason to place the implants or grafts flush with the posterior vertebral border. This may lead, in some cases, to posterior disc material being shoved through the annulus into the spinal canal, to fracture of the posterior vertebral cortex and/or end plate, or to reaming the spinal canal contents with reamers. At the L5-S1 level with a large lordosis, the safety mechanisms in the Spinetech system that keep the implants and reamers from reaching the spinal canal can be overcome by the operating trocar overhanging the sacral promontory and approximating the spinal canal. All such mishaps can be overcome by insisting on clear, non oblique c-arm images and frequent checking during reaming. (Figure 22)

Pre-operative planning for expected implant length will also be helpful. The height of the implant required may vary from your preoperative x-ray assessment depending on disc elasticity, but the length will not.

* The trajectory of approach of the operating trocar to the interspace should be perfectly aligned – both centered to the two end plates and parallel to them. Mark your incision sites on the skin with the c-arm prior to draping. When reaming, hold the operating trocar steadily after checking the
trajectory with the c-arm; wobbling will cause too big a hole and encourage implant migration. Make sure to hold the operating trocar by the inner sleeve which is above the outer sleeve. Make sure the trocar hasn’t migrated off the original site by observing it frequently with the laparoscope during reaming.

* If you are using the Spinetech instrumentation, remember that the centering system presumes that the anterior threshold to the disc is in line with the posterior disc, as is usually the case. However, in cases with anterior osteophytes or marked end plate irregularities, the anterior disc may not be ideally in line with most of the posterior disc. In these cases, be prepared to freehand the placement of the operating trocar, letting the c-arm lateral guide you. This is very difficult presently, because the teeth are not long enough to securely engage the anterior vertebra and the trocar tends to slip off its position during the torque produced from the initial reaming. The soon-to-be-released improved version will make this somewhat easier because of longer tooth design. If you run into this situation, watch the trocar closely with the laparoscope to make sure it does not slip when starting your reaming. If your implant went too deep and lateral stenosis resulted, decompress posteriorly and use a flat head screwdriver to drive the implant anteriorly. The CT scan was a little better, in our experience, than MRI in judging implant encroachment on the spinal canal.
* Thoroughly evacuate the nucleus prior to reaming to prevent tissue being driven posteriorly to the spinal canal.

* For the laparoscopic fusions, position the spine in the amount of lordosis you want the spine to end up in.

* If trocar sites leak, identify them by water test and use Vaseline gauze to improve seal.

* Fortunately, we have only had one retrograde ejaculation in the about 15 males we have done fusions on so far. This was the first one, an L5-S1 level case and it resolved in a couple of weeks. We soon switched to bipolar coagulation in males and try to use little or no coagulation at all in the region of the sympathetics. The exposure over the disc for a discectomy is very small, a square centimeter and we were very attentive not to disturb the sympathetics. On the other hand, the anterior and retroperitoneal dissection is extensive for fusions, yet we have only seen the case mentioned. It appears to us that there must be great individual differences in susceptibility to retrograde ejaculation. Consequently, all males must be fully informed of this potential outcome because it may not be preventable by surgical technique.

* Thrombophlebitis is always a potential in anterior spinal surgery. We have had one case in thirty-two at this time. TED hose and dynamic compression boots should be used during this procedure and continued until ambulation is frequent. Intraoperatively at the levels above L5-S1, retraction of the vena cava and hypogastric vein should be attended to and
periodic release performed.

* Close the abdominal wall fascia to prevent hernias.
Endoscopic posterior lumbar spine surgery

Historical Perspective

In 1951, Hult (6) demonstrated the indirect reduction of intradiscal pressure by anterior annular fenestration via a retroperitoneal approach. A decade later, Smith (26) introduced percutaneous enzymatic dissolution of intervertebral discs with chymopapain. These two seminal events lead to the development by pioneers such as Hijikata, Kambin and Onik, of percutaneous, and finally, endoscopic posterior techniques for lumbar disc removal.

Hijikata, et. al., (4) reported on percutaneous nucleotomy and decompression of disc herniation in 1975. Kambin (9,10,11) followed with development of the posterolateral approach and instrumentation allowing removal of disc material with the aid of high negative pressure. These gave rise to the development of the nucleotome and automated disc removal. (19) Subsequently, Kambin’s group also developed an endoscopic posterolateral approach which is also reported to be reliable, safe and effective within its stated indicated uses. (9)

Rationale

Success of these techniques hinges on three principles: Evacuation, Reduction and Decompression. (9) Removal of the nuclear fragments with the manual instruments accomplishes evacuation.
Reduction is carried out by the addition of suction which establishes a negative pressure in the center of the disc capable of drawing some loose fragments into the path of the instruments. This is also aided by the introduction of flexible pituitary rongeurs which are capable of grasping a wider area within the nucleus. Decompression is accomplished by annular fenestration away from the spinal canal. Rapid decline in in vivo intradiscal pressure has been demonstrated with this technique. 

Indications and contraindications

STRICT inclusion criteria: (Kambin (9,13))

--unremitting persistent radiculopathy at L3-4, L4-5 or L5-S1
--failure of appropriate conservative therapy
--neurologic impairment as reflected by sensory deficits, reflex abnormalities, and motor weakness
--correlative EMG in absence of correlative neuro deficits
--positive tension signs
--correlative imaging studies, i.e., CT/myelogram/MRI
--subligamentous ('contained') HNPs

MUST exclude: (Kambin (13))

--sequestered discs
--bony lateral recess stenosis
--spinal stenosis
--pedicle induced nerve root kinking
--developmental anomalies or tumors
--reherntiations following open procedures or chemonucleolysis
--spondylolisthesis
--cauda equina syndrome

These considered and adhered to, one can reasonably expect G to E results in ~90% at L3-4, ~90% at L4-5, and only ~50% at L5-S1.

Anatomy and technique

Anatomically, the sympathetic fibers in the lumbar spine run ventral to the vertebral bodies and thus out of the path of the posterolaterally introduced instruments. The iliac vessels are also anterior to the bodies. The annulus at the site of fenestration is covered only by fibers of the psoas. The spinal nerve is separated from the annulus by a thin layer of fat and fibers of the psoas. The nerve courses anteriorly and distally after leaving the foramen, and sits anterior to the transverse processes.

The so-called "triangular working zone" is defined as the extrapedicular space allowing safe passage of instruments with the spinal nerve as the anterior boundary, the proximal end plate of the caudal lumbar segment as the inferior boundary, and the superior articular process of the caudal vertebrae as the posterior boundary. (Figure 23)

If one follows the course of posterolaterally introduced
instruments, inserted approximately 9-10cm lateral of midline, parallel with the disc space, the nerve is largely covered (and thus protected) by the zygoaphyseal joints, pedicles and transverse processes.

A small portion between the foramen and the superior border of the transverse process is vulnerable to penetration; however, this is generally avoided by three techniques. First, through the use of a blunt end trocar, which tends to push the root aside rather than piercing it. Second, through insertion parallel to the disc space. Kambin and Brager have shown increased chance of entrance into the neuroforamen when the instruments are angled caudally. Lastly, the endoscope allows direct inspection of the annular fibers immediately prior to use of the fenestrator.

Prophylactic antibiotics are recommended. The patient may be positioned either in the prone or lateral decubitus positions on a radiolucent table. A fluoroscope is positioned perpendicular to the long axis of the spine allowing perfect AP and lateral projections of the disc space under investigation. Anesthesia consists of local skin infiltration superficial to the lumbodorsal fascia, occasionally supplemented by small amounts of short acting narcotics. It is vitally important that the patient not be overly narcotized, as patient-surgeon communication during the procedure is absolutely essential.

Under fluoroscopic guidance, an 18 gauge needle is introduced into the center of the disc space obliquely, in a posterolateral to anteromedial direction beginning approximately 10 cm lateral to the
midline. Pre-operative abdominal CT scan through the disc space allows more precise judgement of angle of approach and avoidance of intraperitoneal puncture. (Figure 24) Discograms are then carried out at the symptomatic level(s) and at least one asymptomatic level (internal control) in order to confirm the concordant nature of the pain.

The next steps vary somewhat depending which endoscopic system one is using, but basically consist of enlarging the needlestick to a puncture large enough to accommodate the trocar. This is accomplished by passing dilators over the guide wire under careful fluoroscopic control. Next, the endoscope is inserted verifying the position of the trocar within the triangular working zone, as well as visualization of the outer annulus. (Figure 25 and 26) The working channel of the scope is then used in order to gain entrance to the nucleus through annular fenestration. (9,13) (Figure 27)

Alternatively, if a working channel scope is not being employed, the endoscope can be carefully exchanged for manual or automated instruments (i.e., the Nucleotome(R), Surgical Dynamics or the intradiscal shaver, Sofamor-Danek), which then carry out the removal of disc material under fluoroscopic guidance with intermittent endoscopic visualization. Surgical Dynamics has recently introduced a flexible probe (the Endoflex), which provides visualization, aspiration, and cutting capabilities through a single portal. (Figure 28)

Posterior endoscopic lumbar discectomy is efficient, cost effective and safe. Hospitalization and recovery time seem to be
decreased. The surgeon must be always cognizant of the strict indications and contraindications, as well as exacting surgical technique in order to experience favorable surgical outcomes and minimize potential complications.
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