Minimal and Direct Access Aortoiliac Reconstructive Surgery

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Despite improvements in surgical practice and postoperative care, the large transperitoneal approaches used in elective aortic reconstructive surgery are still associated with a relatively high perioperative morbidity and mortality rate, even in patients who are good risks for undergoing aortic surgery.[1,2] This perioperative morbidity is partly caused by major surgical trauma.

To decrease the surgical stress on these patients, a less extensive procedure was developed for this type of vascular reconstruction utilizing minilaparotomy and videoendoscopy. The primary purpose of this method is to apply the standard rules of vascular surgery to a less invasive approach in the treatment of aortoiliac obstructive or dilatative disease. Briefly, it means that the abdominal aorta is explored using a special retractor through a small (5 cm) upper median skin incision. Through this "mini" approach a direct, three-dimensional view is achieved and operative stress can be significantly decreased. For tunneling, a new type of videoendoscope has been developed which can also be used for other retroperitoneal manipulation procedures.

Experimental studies were performed on animal models to develop techniques for use with modified instruments in tunneling and suturing procedures. Standardizing each operative step of this new minimal and direct access vascular surgery was developed in cadaver work. These preclinical studies provided the necessary experience and confidence needed to begin clinical application. The studies were approved by the university ethics committee, and informed consent was obtained from patients before surgery. The first patient underwent a minimal and direct access aorto-bifemoral bypass reconstruction on June 19, 1993.

GENERAL PRINCIPLES

Anesthesia

Interventions are performed under combined epidural and general anesthesia with complete hemodynamic monitoring. It is not at all different from that which is performed in conventional surgery. The epidural catheter is placed to the level of the thoracic nerve trunks 8 and 9 for continuous morphine administration. The urinary bladder was decompressed with a Foley catheter and a nasogastric tube to decrease intra-abdominal contents in the stomach.

Position of the Patient and the Surgical Team

The patient is placed in the supine position and securely strapped to the operating table with safety belt at the thighs. The right arm is tucked at the bedside, and the left arm is extended on an armboard.

The surgical team is comprised of the operating surgeon, his assistant, and the operating room nurse. The operating surgeon is at the right, and the assistant and the scrub nurse stand on the left side of the patient.

Video equipment components are all mounted on a trolley. This equipment consists of two monitors laterally tilted (one for the surgeon and the other for the assistant), one cold light source for the endoscope and for additional spotlights, a video cassette recorder and optional irrigation equipment. This trolley is positioned at the foot of the patient against the operating table.

Preparation of the Operating Field

The patient is prepared and draped for traditional aorto-bifemoral reconstruction to allow conversion from the minilaparotomy to the conventional approach.

SURGICAL INSTRUMENTATION

The essential design features of instruments for this approach are designed to facilitate coordinated, efficient movements in restricted operating space. Generally their tips are curved and have an angled or bayonet shape and indented shanks to enable various manipulations. The principle underlying the use of the distal arc and angled or bayonet instruments is that simple axial rotation allows a full (360°) range of movement of the instrument tip. They are designed in accordance with anatomical and functional requirements.

1. The bayonet-shaped forceps has curved jaws. This curve allows edges of arteriotomy and graft to be grasped sideways, providing stability for entrance or exit needle passages.
2. The suction forceps is a multi-function instrument allowing the surgeon to suture, anastomose, and clear the operating field, eliminating the need for a separate suction instrument.
3. The curved tip needle holder is designed to handle, hold, and drive the needle optimally. Its jaws can handle different sizes of needles and sutures, from 2-0 to 7-0.

Retractor System (Jakoscope)

Retraction to gain exposure of the abdominal aorta has two components: retraction of the abdominal wall musculature, and retraction of the abdominal viscera and retroperitoneal tissues. When the small bowel is cephalad, this is an ideal circumstance for using a localized retraction. Positioning of the table in the Trendelenburg position (20–30°) and tilting it to the right (15–20°) helps to keep the loops of small bowel away from the pelvis.

Videotunneler

Initially tunnels were created by blunt dissection with the index fingers and were continued gently with a blunt tunneling device along the anterior surface of the iliac arteries. During this minimally invasive maneuver, special care was exercised to avoid troublesome hemorrhage from iliac and other vein lacerations. To overcome these difficulties, a new tunneling device, "fiberscope," was developed which allows us to have visual control of the tunneling procedure. It contains a semi-flexible, transparent tube with an inflatable balloon at the tip of the tube.

It measures 8 mm in inner diameter, 2 mm of wall thickness, and 400 mm of length. The valve at the other end provides gas and waterproof connections of fiberscope and tube.

The working channel of the fiberscope is used for irrigation and suction of the operative or tunneling field, although this channel can also be used to employ scissors, a dilator forceps, or a second balloon as well.

The prototype device used in this study was a simple combination of an endotracheal tube and a bronchoscope. It has been tested in a series of cadaver experiments and clear visualization of tunneling procedure was always possible. To date, we have used this device in 27 abdominal vascular reconstructions. The visually controlled balloon dissection is technically feasible and clinically safe. As the device is further being developed, more research is necessary to evaluate the benefits of this technique and further application possibilities.

OPERATIVE TECHNIQUE

This technique is performed like conventional aortoiliac surgery, only the method of access to the aorta has changed. The procedure is divided into five steps with special attention focused on the efficient execution of each. Following the standard "step-by-step" technique is necessary in order to increase the feasibility of this method.

Operative Steps (Table 1)

1. Exposure of the infrarenal aortic segment.

The abdominal aorta is approached through a small (10–12 cm) upper median incision. The incision should be the same size as the surgeon's hand, allowing exploration of the intra-abdominal and periaortic spaces and target vessels by palpation. After the careful investigation of intra-abdominal conditions, the patient is moved to a 20–30° head down (Trendelenburg) position, turned to the right side to permit upward migration of

Table 1. Operative steps

1. Exposure of the infrarenal aortic segment
    a. upper median incision
    b. special retractor
    c. "hand-over-hand" technique
    d. small bowel not exteriorized
    e. peritoneal surface is covered with moist towels
    f. operating space is cautiously isolated
    g. modified hand instruments
2. Videotunneling: creating the retroperitoneal tunnels for the graft
3. Suturing the aortic anastomosis
   suturing technique: oblique, rotated grip or combined grip
4. Pulling graft through the previously created tunnel
5. Suturing the femoral anastomosis

the bowel loops. Using a gentle "hand-over-hand" technique, the small bowel is packed into the right gutter and moist toweling is placed in the abdomen to cover all the exposed viscera. Avoiding bowel evisceration has a significant effect in decreasing the postoperative paralytic ileus. The next step is to proceed with mobilizing the duodenum away from the aorta. With this method precise preparation and proper hemostasis are essential. Prior to clamping the aorta, the retractor is positioned to hold the viscera away from the deep retroperitoneal aorta. The length of blades used depends upon the thickness of the patient's abdomen. The advantage of using the special retractor for abdominal wall muscles, periaortic tissue, and viscera is that the surgeon is less likely to compress the colon, small bowel, or mesenteric portal vein against the abdominal wall. During the operation it is vital not to injure the abdominal tissues with overzealous retraction. Downward pressure is placed on the retractor blades, pushing them against the vertebral bodies; this maneuver restrains the abdominal viscera and toweling that has been placed into the retroperitoneal space. The aorta is encircled with a silicone loop proximal and distal to planned anastomotic site. To enhance this maneuver, a special bayonet-shaped device with curved tip is used.

2. Creation of the retroperitoneal tunnels for the graft: videotunneling.

The tunnels are created by blunt dissection with the index fingers along the course of the external iliac arteries. This blunt dissection is continued gently with the videotunneler through stepwise insufflation of the balloon. The tip of the videotunneler is gradually advanced along the anterior surface of the common iliac artery, separating the layers of retroperitoneal space. Anatomical landmarks are visible through the transparent balloon and tube. The proximal outlet of the tunnel is created using the index finger. When tunneling is completed (when the instrument reaches the periaortic region) a good view of the nearby retroperitoneal structures is possible.

The endoscope is then withdrawn, and through the tube two silicone loops are inserted on the right side; after that, the tube is removed. At the distal end of a silicone loop a suction drain is fixed and pulled through the tunnel into the periaortic space. This drain is used for intra- and postoperative suction. It is removed on postoperative day 2. The other silicone loop maintains the direction of the tunnel and enhances the correct anatomical placement of the graft.

3. Suturing the proximal anastomosis.

Straight vascular clamps are placed proximal and distal to the planned anastomotic site. When end-to-side3 aortic anastomosis is planned, a side exclusion of the aorta can be also performed. These clamps must overcome arterial pressure and resist the slipping force caused by this pressure. Using internal suction through the tunnel and the suction forceps, blood is continuously removed. This assures a clear field which improves the visibility and the safety of this technique.

A special suturing technique is used because if the needle grip required is selected and requires a larger arc than is available in operating space, the suture cannot be completed as intended because the needle will miss the correct exit point (e.g., half-circle needle). It has the potential to produce a greater suture span, larger tissue bite, and the tissue can be distorted or even torn. In our experience the standard or straight

Figure 1. Square knot tying sequence.

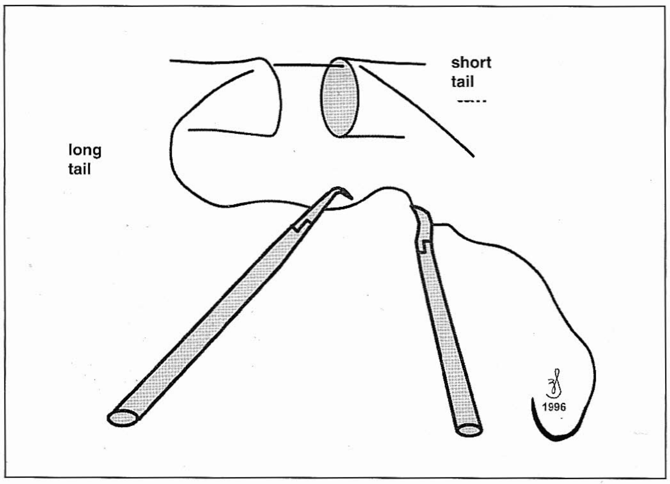

Figure 1a. Starting position.

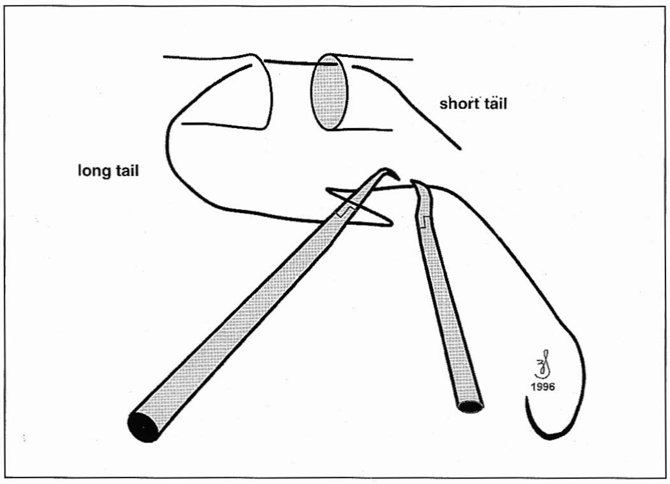

Figure 1b. Creating a loop around the instrument tip and grasping the short tail. If a surgeon's knot is needed a double throw is used.

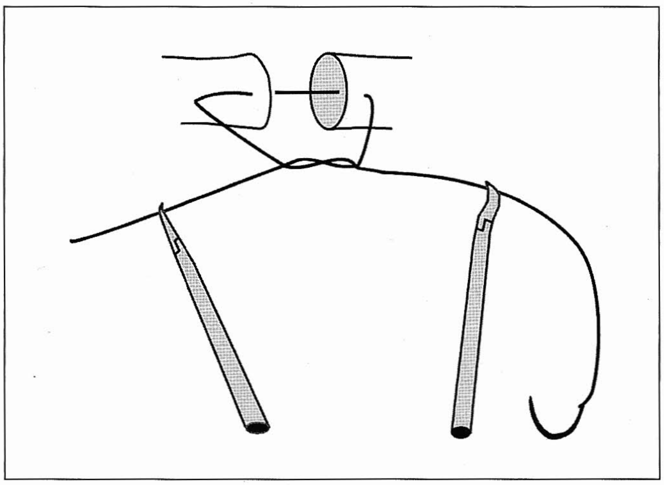

Figure 1c. Pulling it through the loop forming the first flat knot.

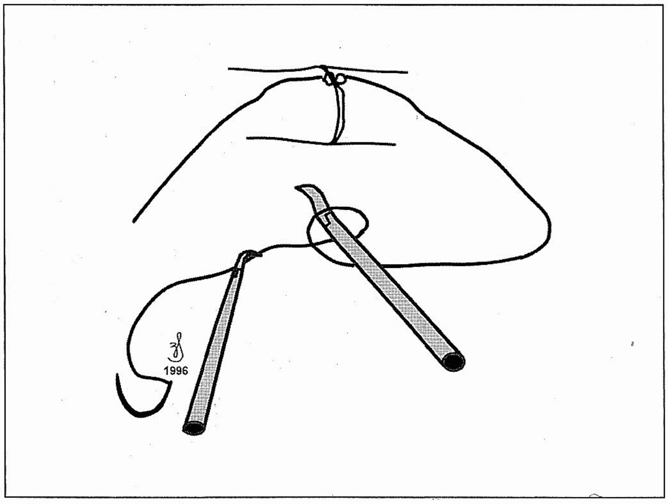

Figure 1d. Creating the opposite starting position, looping thread around the needle driving instrument, then grasping the short tail.

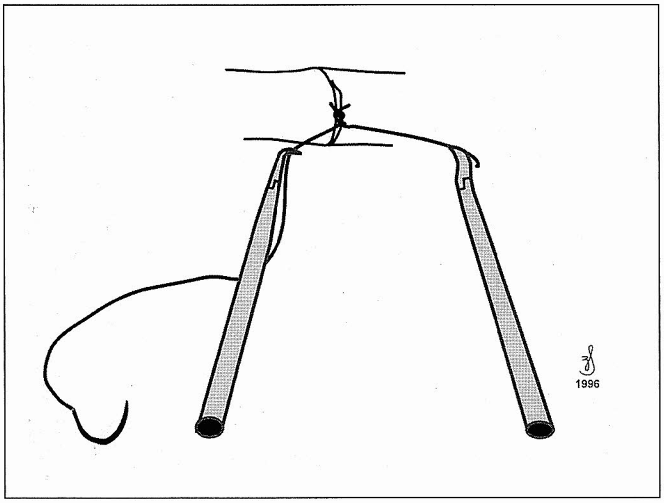

Figure 1e. Pulling the short tail through; the square knot is tightened perpendicular to the suture line.

Figure 2. Aberdeen knot tying sequence:

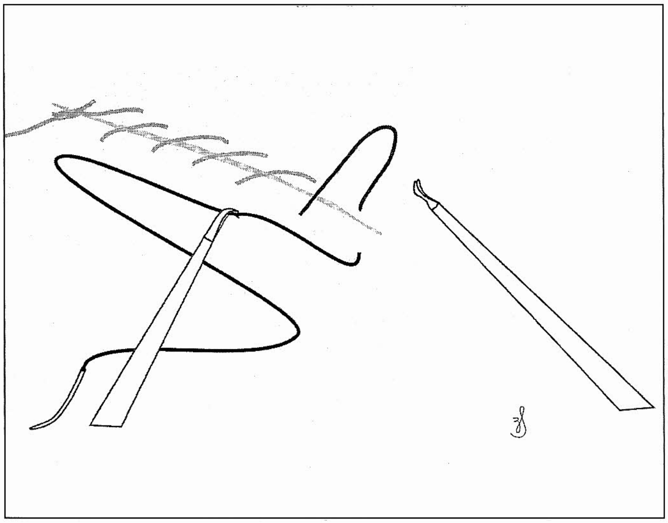

Figure 2a. Last loop is opened up and the long tail is held taut with the assisting grasper.

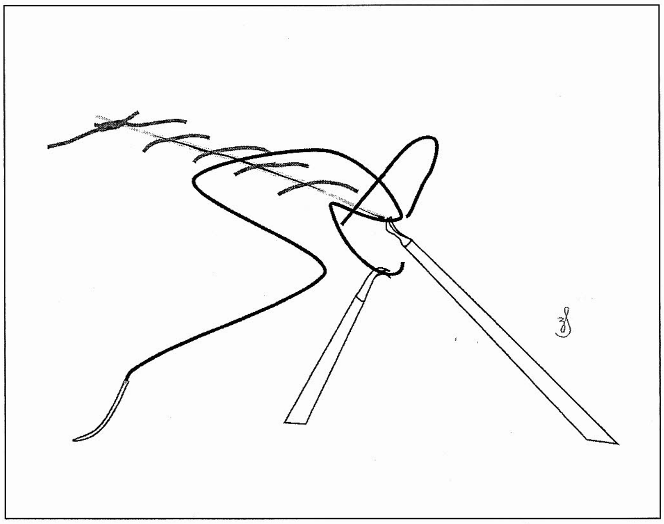

Figure 2b. Needle driver reaches through the last loop, grabbing the long tail near the assisting grasper and pulling part of the long tail through the loop, tightening it, thereby creating a new loop.

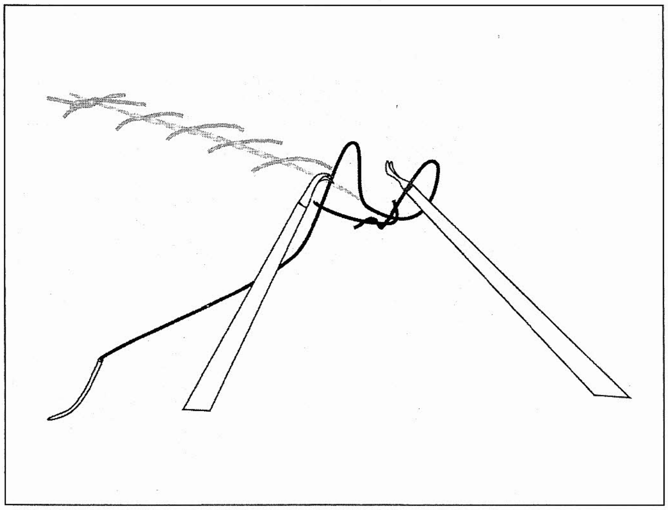

Figure 2c. Repeating this several times, depending on the suture material.

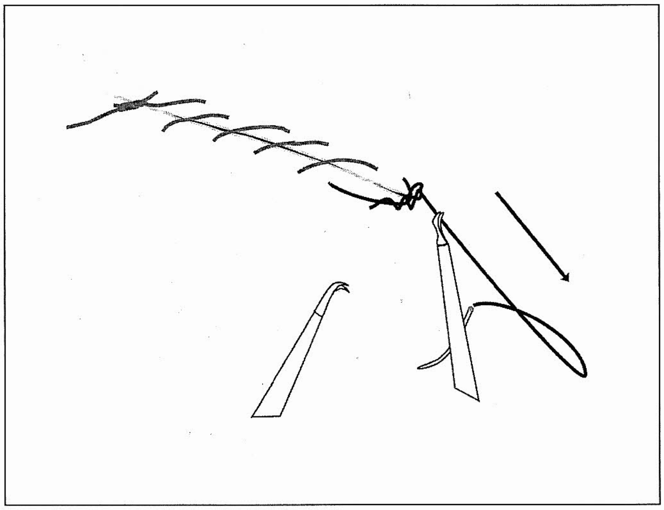

Figure 2d. To lock it, the thread with the needle is completely pulled through and tightened.

Table 2. Procedures performed via minilaparotomy

Procedures	No.
Aorto-bifemoral bypass	18
Iliofemoral bypass	5
Aorto-femoral bypass	2
Aorto-bi-iliac thromboendarterectomy	2
Total	27

Table 3. Patient history

Demographics	
Total no. of patients	n=20
Mean age range (years)	52 (41-70)
Sex	5F + 22M
Associated disease	
Hypertension	12
Coronary artery disease	13
Diabetes mellitus	4
Chronic obstructive pulmonary disease	6
Smoking	17

Table 4. Postoperative outcome of treatment of aortoiliac occlusive disease with the minilaparotomy approach

Approach	Conventional	Minilaparotomy	
Number of cases	14	16	
Nasogastric drainage, hrs	64±14	8±3	$p< 0.01$
Bowel movement, hrs	72±10	48±6	$p< 0.05$
Initiation of alimentation, hrs	96±18	60±12	$p< 0.05$
Intensive care stay, hrs	96±20	0	
Hospitalization, days	9±3	6±2	$p< 0.05$

grip, by which the needle is at right angles to the jaw and the long axis of the needle holder, could not be used in this restricted field. We should use, alternatively, the *oblique grip*, by which the needle plane is shifted different degrees along the long axis, and the *rotated grip*, which keeps the needle plane at a right angle to the long axis but shifts it to different degrees with respect to the jaw plane. Sometimes the *combined grip*, by which the needle plane is rotated after being shifted obliquely, is most appropriate. The suturing methods proposed as optimum leave several options to the surgeon. For instance, as the first grip for the restricted operating space, three types of needle grips are possible, but the point of gripping the needle differs in each case. The grip is at the end of the needle with the *rotated grip*, in the middle of the needle with the *oblique grip*, and at the first quarter point of the needle with the combined grip. The short grip also increases the maneuverability of the needle.

The knotting technique has to be precisely choreographed to provide a secure knot in this tight space. The microsurgical[4] or laparoscopic square knot[5] technique is used which is secure and efficient for placing an interrupted stitch or beginning a continuous suture line (Fig. 1). The continuous suture line can be finished with a three-legged knot[6] or an Aberdeen (crochet) knot[7] (Fig. 2), which is simpler.

At the completion of the proximal aortic anastomosis, tension on the retraction blades should be relaxed as much as possible to prevent compromise of the mesenteric arterial and portal vein flow by overzealous compression. This will also prevent contusion-type injuries against the small bowel, colon, and mesenteric tissues.

4. Pulling grafts through the previously created tunnel.
The distal end of the graft limb is attached (by ligature or suture) to the previously inserted silicone loop and then pulled carefully through the tunnel into the subinguinal region.

5. Suturing the femoral anastomosis.
The anastomotic suture line is like that of the open technique. After careful inspection of all anastomoses and working spaces, suction drains are placed and all skin incisions are closed.

RESULTS

To date, 27 patients have been operated with this method (Table 2). In one case conversion to laparotomy was necessary. The operating time averaged 2.5 hours and only one assistant was necessary.

Patient ages in this series ranged from 41 to 70 years and the majority were males. Their disease states also varied (Table 3).

The postoperative outcome in patients undergoing the minilaparotomy approach for treatment of aortoiliac occlusive disease is presented (Table 4).

The postoperative recovery was compared in two groups of patients: nasogastric drainage was significantly shorter; bowel movement and initiation of alimentation was begun significantly earlier in minilaparotomy group. Patients could generally take fluids on the first postoperative day, receive a light meal on the second postoperative day, and normal meals thereafter. No intensive care was necessary.

The mean duration of the postoperative hospital stay was also significantly less (6±2 days) compared to the conventional exploration of 9±3 days. Generally, the patients operated by this method required less analgesia, had shorter hospital stays, and expressed more "overall satisfaction."

In these two groups, spirometry was performed postoperatively for 5 days. Both groups of patients showed a significant decrease in vital capacity and forced expiration volume postoperatively, with the tendency to return to normal by the 5th postoperative day. The forced vital capacity was depressed to 45% of the preoperative value in the conventional group compared with 57% in the "minilaparotomy" group at 24 hours after operation. By the 5th postoperative day, it had increased to 71% of the preoperative value in the conventional group compared with 80% in the "minilaparotomy" group.

The forced expiration volume was

Table 5. Advantages of the "mini" approach in aortoiliac reconstructive surgery: effects of reduced trauma and pain

1. Pulmonary

Lower reduction on pulmonary function
Lower incidence of respiratory complications

2. Wound Healing

Smaller wound surface
Decreased contamination rate
More rapid healing
Improved functional recovery
Absence of laparotomy wound complications

3. Bowel

Small bowel not exteriorized
Decreased mechanical irritation of the small bowel
Decreased mesenteric traction
Minimal peritoneal fluid loss

Reduced fluid requirement
Earlier return of bowel function
Decreased abdominal discomfort
Lowered incidence of paralytic ileus

4. Economics

Only one surgical assistant needed
Reduced need for intensive care
Shorter hospital stay
Improved overall financial consequences

Table 6. Aortoiliac reconstructive surgery: indications and contraindications

Indications

Aorto(bi)femoral bypass
Iliofemoral bypass
Iliofemoral TEA

Contraindications

Previous aortoiliac or other retroperitoneal operation
Complex intra-abdominal vascular reconstruction
Relative obesity

depressed to 48% of the preoperative value in the conventional group compared with 60% in the "minilaparotomy" group at 24 hours after operation. By the 5th postoperative day it had increased to 76% of the preoperative value in the conventional group compared with 82% in the "minilaparotomy" group.

The changes in vital capacity and forced expiration volume showed statistically significant differences between the two groups. These changes, along with a reduced ability to cough, can lead to the development of microatelectasis and pulmonary infections.

DISCUSSION

Numerous advantages have been noted in the treatment of aortoiliac occlusive disease via minilaparotomy over conventional technique (Table 5).

The small size of incision, the limitation of the exposure, and early removal of skin sutures (on 5th postoperative day) all contribute to minimizing pain. In addition to avoidance of large, painful access wounds, the instruments used for tunneling are fine and thus the tissue trauma is reduced further. It is also an important advantage of this technique that the minimal exploration minimizes risk of injury to preaortic autonomic nerves and the postreconstructive impotence rate will decrease.

The decreased abdominal pain and discomfort during the period of recovery and lowered incidence of paralytic ileus and associated pulmonary complications in themselves would appear to justify the use of this "minimal" exposure. Patient benefits from this technique have been demonstrated in terms of improved functional recovery and absence of large laparotomy-related complications as well as a more rapid return to active life.

In the case of conventional operation, the evisceration of the small bowel in preparation for aortic reconstruction has a pronounced hemodynamic effect. During the miniexploration there is no such exteriorization. Because of minimal intra-abdominal exposure, desiccation and manipulation of the small bowel is also less, which accounts for the reduced fluid requirement and earlier return of bowel function.

CONCLUSION

Experience from this series has demonstrated that this method decreases surgical stress without endangering the safety of the patient during any point of operation. In case of unexpected intraoperative difficulties or complications, the small incision can be promptly converted to conventional laparotomy.

Our experiences proved that this "mini" approach may be used for 5 bypass or thromboendarterectomy. This approach is not possible in all circumstances (Table 6), particularly in the presence of scar formation from previous aortoiliac or other retroperitoneal operations[8,9] or in cases of complex intra-abdominal vascular reconstruction. Morbid obesity was considered a contraindication but the minimal access exploration is especially beneficial to obese patients due to their tendency towards lower incidence of respiratory and great wound-related complications postoperatively with minimal access surgery.

Privileging for this procedure is problematic, however. It demands only basic retracting, dissecting, and suturing skills, and can be granted at an earlier stage in training than for completely video-guided minimally invasive vascular surgery. STI

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