Original Contribution

MINI-INVASIVE SURGICAL APPROACHES TO THE AORTO-ILIAC SEGMENT

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ABSTRACT
Traditional open surgery of the abdominal aorta and iliac segment is a surgical intervention with a relatively high risk and well-studied perioperative mortality. Over the last decade, there has been a constantly growing trend to reduce surgical trauma in the treatment of vascular diseases. The right choice of a vascular approach is crucial for the success of every open aorto-iliac vascular reconstruction. The mini-invasive vascular approaches offer significant advantages over classic surgery and are associated with better perioperative results.

Key words: mini-invasive surgery, aorto-iliac occlusive diseases, abdominal aortic aneurysm, vascular approaches, abdominal aorta, iliac arteries

INTRODUCTION

Aorto-iliac occlusive disease (AIOD) is a chronic, progressive and often asymptomatic disease that leads to stenotic-obliterative and aneurysmal changes in the abdominal aorta, iliac arteries and in some cases it can affect the arterial vessels below the inguinal ligament. AIOD is a variant of peripheral artery disease (PAD) and in fact, the aorto-iliac segment is the most common location of arterial lesions in above 50% of the cases [1, 2]. The main etiological factor for the progression of the disease is atherosclerosis and it is observed in 90% of patients [3, 4]. Epidemiological studies report that incidence ranges between 3-10%, increasing to 15-20% in patients aged over 70 and over 23% in patients above 80 [5-7]. The most pronounced risk factors for AIOD are smoking, diabetes, male gender, obesity, family history, aortoarteritis, systematic connective tissue disorders and etc. AIOD might remain asymptomatic for years, however in 15-20 % of the patients, the progression of the disease is associated with critical limb ischemia with/without severe disability and high mortality within one year after the onset [8-11].

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Operative treatment strategies include elective open surgery and endovascular therapy [12, 13].

Open elective surgical intervention of the aorto-iliac segment has proven to be one of the most successful in vascular surgery of all time, with great reliability and durability, combining both high patency and excellent long-term results [14-16]. The incidence of the perioperative complications of aorto-iliac reconstructions ranges between 5-10% with mortality rates between 3.3 and 4.3% [17 - 19]. Postoperative complications are divided into systemic and local and both are strongly related to the choice of surgical approach [20, 21]. The type of vascular approach is crucial for the success of every surgical intervention. The choice of a surgical incision in the abdomen is determined by: the vascular pathology, the procedure (emergency/planned), the habitus and specific anatomy of the patient, history of surgery, concomitant diseases and also personal preferences, experience and skills of the surgeon. Open-operative treatment of AIOD includes the use of extraperitoneal and transperitoneal surgical approaches [22]. Mini-invasive modifications of both surgical methods carry certain operative advantages over the classic surgical approaches such as less surgical trauma, shortened intraoperative time less postoperative complications and are very applicable in high-risk patients [23, 24].

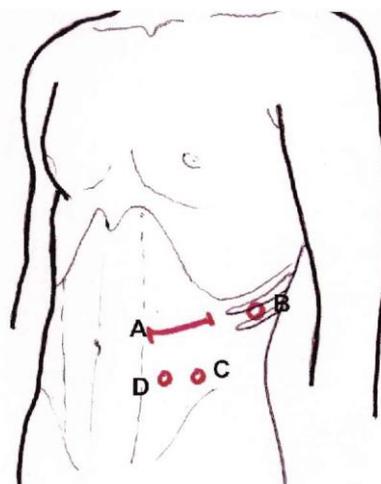## Mini-invasive retroperitoneal approach

Mini-invasive retroperitoneal approaches combine the benefits of classic retroperitoneal approaches, and even in some cases are superior to them [25]. Mini-invasive extraperitoneal approaches demand exceptional surgical precision and high-quality diagnostics. There are certain limitations concerning the implementation of the retroperitoneal mini-invasive approaches in patients with uncommon vascular pathology (giant abdominal aneurysms, complexed traumas etc) and especially in emergency cases [26]

Piquet et al. reported on 150 patients who underwent minimally invasive retroperitoneal access for infrarenal aortic aneurysm (130 patients) and aorto-iliac occlusive disease (20 patients) over a four-year period from 2000 until 2004 [27]. The patient is placed on the operating table in the right lateral decubitus position. The left knee is slightly flexed with the left lower extremity in adduction in order to maximally relax the left m. ileo psoas. The operating table is folded right into the patient's hip area to ensure maximum exposure. The patient's pelvis can be rotated posteriorly if access to both groins is needed during surgery. The exact orientation of the mini-incision is determined by the length of the aneurysmal neck. Typically, the transverse incision begins 5 cm from the apex of the 11th rib and ends at the lateral edge of the left m.rectus abdominis. The length of the incision varies from 6 to 12 cm. The abdominal muscles are divided along the incision. The dissection of the retroperitoneal space is done in blunt manner and starts from the lateral pole of the incision. The presentation then continues cranially until the perirenal fascia is reached and the m. ileo psoas. The left ureter and kidney are retracted anteromedially using a system of three automatic retractors (Unitract, Aesculap, and Pilling), monitoring for possible iatrogenic trauma due to traction of the ureter. The left kidney is lifted, with the help of one of the retractors, while the other two retractors evacuate the peritoneum and its contents medially. Proximal aortic control demands identification of the left renal artery. Before performing conventional aneurysmal neck dissection, a 10 mm trocar is placed over the iliac crest and a zero-degree laparoscope is then inserted. This method does not require a complete representation of the aortic circumference. Clamping of the abdominal aorta is facilitated with two aortic clamps (CardioVasive Chitwood DeBakey clamp, Scanlan) that are placed through a miniscule

incision lateral to the initial incision, by this maneuver the range of the operative field is increased (**Figure 1**)
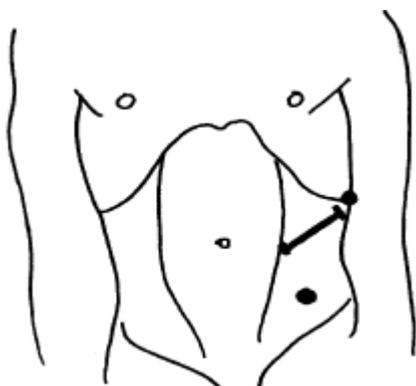

Figure 1. Mini-invasive retroperitoneal access to the abdominal aorta. Incision line (A), the incision site for the insertion of the aortic clamps(B), the position of the camera and the graft insertion site (C and D) [27]

The minimally invasive surgical technique for the operative treatment of aorto-iliac occlusive disease does not differ from the traditional retroperitoneal approach to the infrarenal aorta, except for the presence of femoral incision to one or for both common femoral arteries [28]. The minimally invasive approach described is applicable when performing left aortofemoral bypass. aortobifemoral bypass, biiliac bypass, as well as endarterectomy of the iliac arteries, etc [29].

Cardon et al. described 32 patients operated for infrarenal aortic aneurysm with a mini-invasive retroperitoneal approach and a video-assisted technique applied to perform the aortic anastomoses [30]. This combined surgical technique is performed under certain conditions: neck length of the infrarenal aneurysm at least 2 cm or more; absence of the aneurysm of the right internal artery, as well as the need to perform the reconstruction of the bifurcation of the right iliac artery and no history of previous surgical intervention in the left retroperitoneal space. The patient is positioned on the operating table in the right lateral decubitus position. The patient's pelvis remains horizontal, allowing access to the femoral arteries. The left hand is mobilized and taken slightly away from the body. The incision starts from the lateral edge of the left m. rectus abdominis, 1 cm above the navel and ends at the apex of the 11th rib (**Figure 2**). The length of

the incision is from 8 to 10 cm. The level of incision varies depending on the length of the proximal neck of the abdominal aneurysm. If the aneurysm neck is short or an aortobifemoral bypass is planned, the incision is placed as high as possible. This provides direct access and control of the aneurysmal neck near the renal arteries, however performing a distal anastomosis at the level of the iliac arteries is excluded. The muscles of the anterior abdominal wall are divided along the course of the muscle fibers. The peritoneum is freed and taken medially. In this position, it becomes possible to prepare the infrarenal aorta and its bifurcation. Control of the right iliac bifurcation is extremely difficult due to the poor exposure. A thirty-degree laparoscope is installed through an 8- to 12 -mm trocar. The trocar is placed between the surgical incision and the inguinal ligament. Presentation of the posterior wall of the infrarenal abdominal aneurysm and clipping of the left lumbar arteries is performed using the installed thirty-degree laparoscope. The video-assisted technique helps to precisely clip the right lumbar arteries as well, without limiting the scope of the operative field. Clamping of the aorta is performed through a small incision at the level of the 11th rib [30].

Figure 2. Mini-invasive retroperitoneal approach, combined with video-assisted surgical technique [30].

Andrási et al. present an open mini-invasive retroperitoneal approach to the abdominal aorta and iliac arteries for the surgical treatment of aorto-iliac occlusive disease. They report about 5 patients who underwent aorto-bifemoral bypass with two mini-invasive approaches to the infrarenal aorta and two mini-femoral approaches along the course of the inguinal ligament. The first supraumbilical vertical incision is 8 cm long, while the second infraumbilical incision is about 2 cm (**Figure 3**) [31].
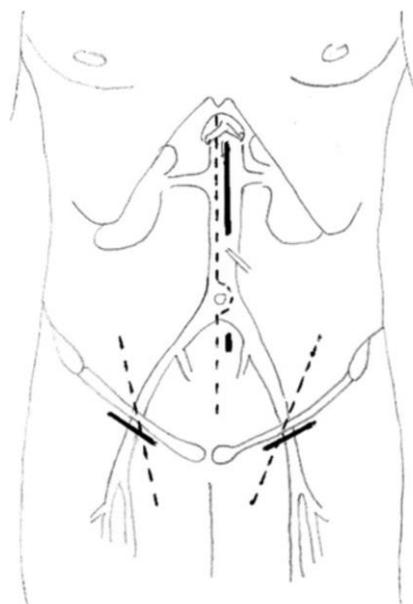
Figure 3. Mini-invasive retroperitoneal approach and bi-femoral approach. Incision lines placement [31].

After the surgical wound is opened, the transverse column and omentum are mobilized cranially using a "Thompson" - type retractor. The small intestines remain in their anatomical place and are deviated slightly to the right, and then the posterior peritoneum, which covers the infrarenal aorta is visualized. A two-centimeter longitudinal incision is made in the posterior peritoneum, between the duodenum and the left mesenteric vein, visualizing the left renal vein. After retraction of the duodenum to the right and the left renal vein in a cranial direction, 2/3 of the circumference of the aorta can be safely mobilized. Exposure of the infrarenal aorta is limited up to 3 cm to prevent possible damage to autonomic nerves. infraumbilical vertical incision, distal clamping of the aorta is performed. One centimeter infraumbilical vertical incision is performed, which ensures the placement of the distal clamp outside the operative field-transperitoneally. Exposure of the two femoral arteries is accomplished through two mini transverse infrainguinal incisions of approximately 4 cm in length each.

Mini-invasive transperitoneal approaches
In 2000 and 2001 Turnipseed et al published a study using a minimally invasive transperitoneal approach in 70 patients [32, 33]. The authors evaluated both the clinical and economic impact of minimal incisional aortic surgery in the operative treatment of patients with aortic aneurysms and aortoiliac occlusive disease.

The average length of the periumbilical longitudinal incision is between 8 - 10 cm and its direction depends entirely on the type and localization of the vascular pathology. In patients with infrarenal aortic aneurysms, a minilaparotomy was performed. The skin incision is oriented cranially and its average length is about 8 cm, while in patients with aortoiliac diseases the 6-8 cm incision is positioned in a caudal direction. The efficiency of the surgical approach to a large extend is determined by the preliminary relaxation of the anterior abdominal wall. Sufficient muscle relaxation is mandatory and it provides enough mobility (to be extended proximally or distally) and enough surgical space for a one hand manipulation (**Figure 4A, 4B**).

A   **B**
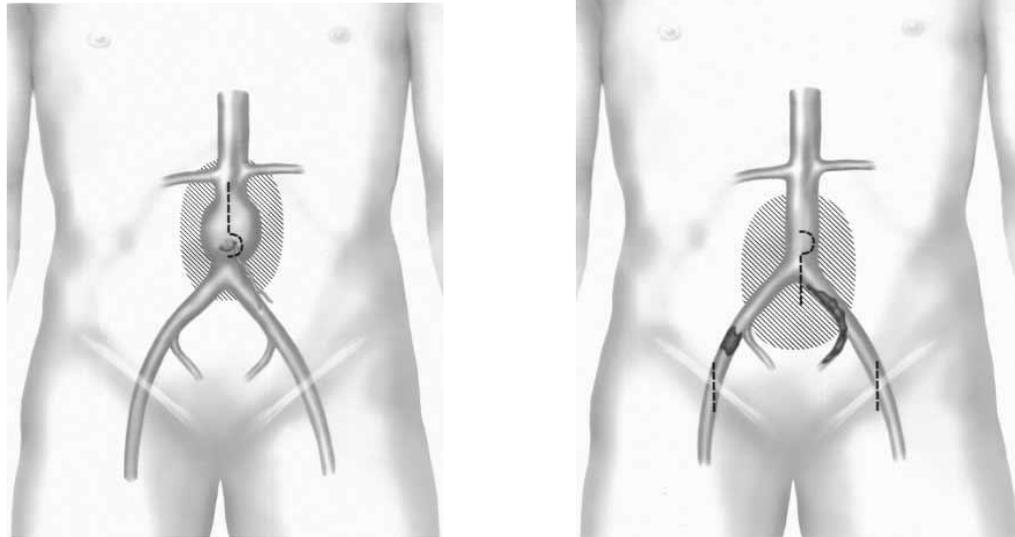
Figure 4. Transperitoneal Minilaparatomy. Modification A – orientation of the skin incision for infraaortic aneurysm. Modification B – orientation of the skin incision for aortoiliac occlusive disease. Modification A facilitates excellent access to the abdominal aorta from the level of the renal arteries to the aortic bifurcation, while modification B of the mini-invasive transpertioneal approach provides exposure to the aortic bifurcation and to the iliac bifurcation distally [32, 33].

As with standard midline laparotomy, the operative wound is opened in layers, the small intestines are immobilized slightly cranially and to the right of the abdominal aorta. Then a rubber pad, viscera retainer is placed, which allows expansion of the operative field and facilitates the manipulation of proximal and distal external to the aorta more easily. This weakly distensible barrier effectively isolates the operative field and prevents the entry of the small intestine into it.


Figure 5. Placing a viscera retainer ”The fish, Glassman” [33].

Further, a low-profile ring retractor is then placed, with individual metal arms positioned at 2 o'clock, 5 o'clock, and 11 o'clock, thus achieving optimal presentation of the operative field and the aorto-iliac segment.

In 2002, Matsumoto et. al. published a report evaluating the effectiveness of the minimally invasive vascular surgery of the aorto-iliac segment in 20 patients with abdominal aortic aneurysm (AAA) and mean size of the sac 4.6 ±0.7 cm. The control group consisted of 14 patients with AAA, aneurysm diameter 5.4 ±1.0 cm, operated with the use of a conventional midline laparotomy [34]. Perioperative results clearly revealed shorter hospital and ICU stay, earlier oral intake, less fluid resuscitation and less surgical trauma in the patients with a minimally invasive approach.

The patient is placed in the supine position and the operating table is in a retroflexion position – "reversed jackknife"/arched back position. Sometimes a sand/water pad can be placed under the patient`s back. If exposure of the iliac arteries is needed, the patient is placed in the horizontal position to allow relaxation of the abdominal muscles and skin in order to facilitate easy and fast access.
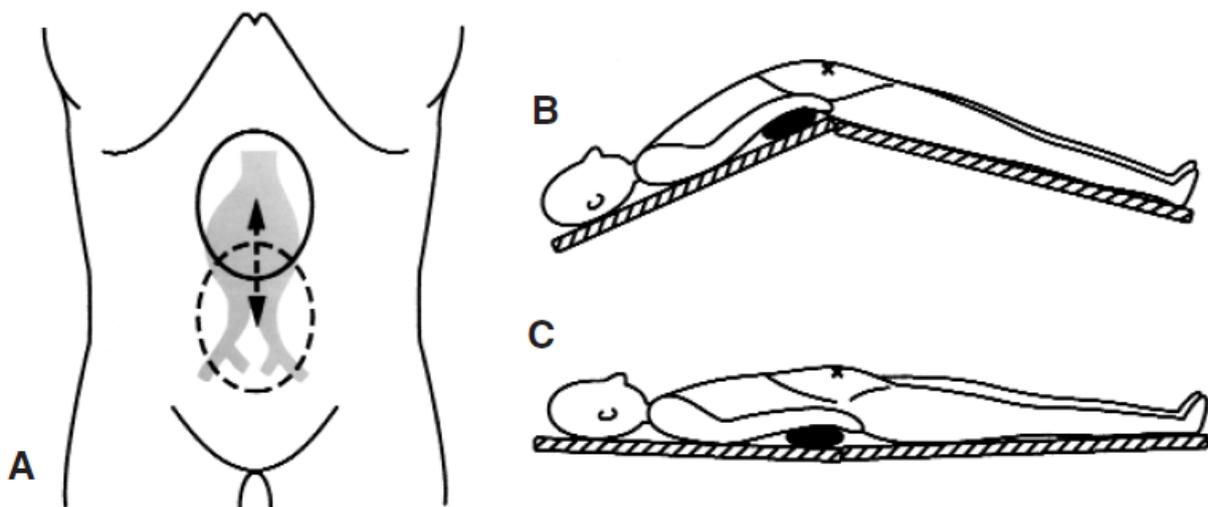

Figure 6. Patient`s position on the operating table. Ultrasound verification of the aneurysm neck [34].

The beginning of the incision is determined by the position of the aneurysm neck, preliminary verified by ultrasound scanning and marking of the aneurysm sac. The skin incision length does not exceed 10 cm in order to minimize the surgical trauma and it stars 3 cm above the aneurysm neck. Typically, the operative wound is opened in layers and after entering the peritoneal cavity the small bowel is mobilized and brought up and to the right of the midline. The aneurysmal neck is presented with retraction of the retroperitoneum in a proximal direction by installing specially developed hard retractors of the "MERA copper retractors, Senkoikakogy, Tokyo, Japan". After that, the retroperitoneal exposure and dissection of the abdominal aorta are performed according to the classic technique.
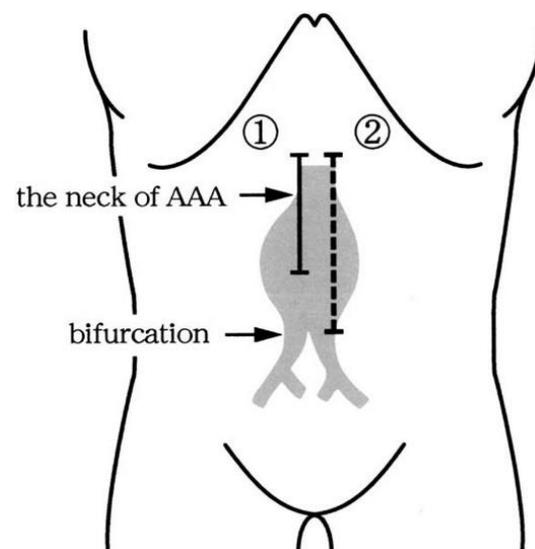

Figure 7. Skin incision of the mini-invasive transperitoneal approach [34].

The transverse minilaparotomy is another less invasive operative technique that is used in high-risk patients, with straight non-inflammatory aneurysm sacs and no history of previous abdominal surgery [35]. The transverse skin incision is made 2 cm above the umbilicus and it is between 8 and 12 cm long (**Figure 8**) [36]. The operative wound is opened in layers and consecutively the muscle groups of the abdominal wall (m.obliques internus, m.obliques externus, m.transversus abdominis and m.rectus abdominis) are electrocautery cut. After the incision of the peritoneum, an automatic retractor with smooth and deep arms is placed in order to provide enough room for retroperitoneal dissection. The vascular approach is applicable for the operative treatment of aorto- aortoiliac occlusive disease and AAA but is not recommended in patients with vascular pathology affecting both iliac arteries.
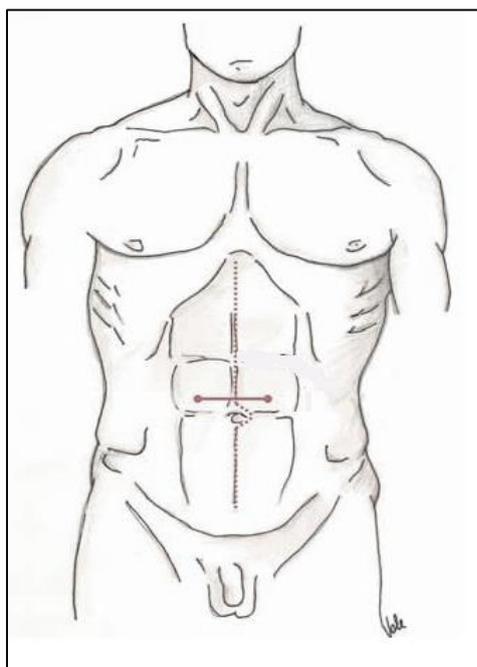
Figure 8. Mini-ininvasive aortic approach. Transverse minilaparotomy [36].

Another variant of the transverse minilaparotomy is the left transverse subcostal minilaparotomy. The vascular approach represents as an alternative to bilateral subcostal access. The skin incision is curved along the costal arc. It begins just below the level of the medioclavicular line and ends 5-6 cm above the navel at the lateral edge of the m.rectus abdominis sin. After the incision reaches the superficial fascia of the left m.rectus abdominis, the latter is cut horizontally and laterally to the fascia of the m.obliqus internus abdominis [37].
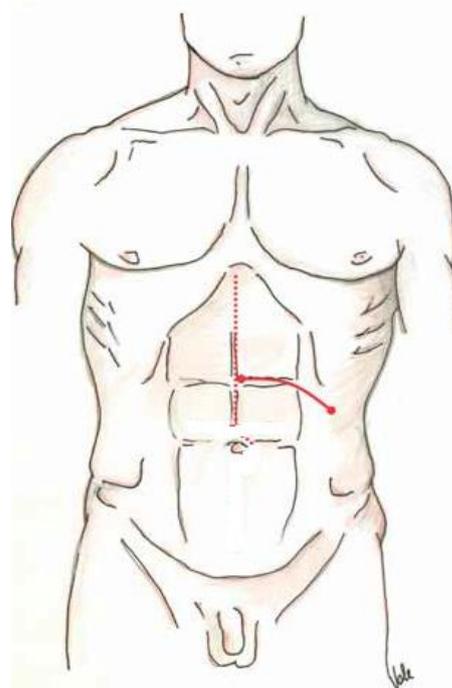
Figure 9. Skin incision orientation in left transverse subcostal minilaparotomy [37].

The length of the incision varies between 10 and 15 cm and largely depends on the width of the m.rectus abdominis sin., which is often correlated with the patient's body mass. The muscle is divided using electrocautery which is less traumatic, and is followed by a lower incidence of wound hematomas than by division and traction of the muscle. Once the peritoneal cavity is entered, the small bowel is mobilized and adducted to the right and the retroperitoneal space is presented and the abdominal aorta is dissected as described. The flexibility of this vascular approach allows the placement of the automatic retractor and aortic clamps without the need the further expansion of the approach, as well as the additional application of muscle relaxants.

CONCLUSION
Undoubtedly, mini-invasive surgical approaches represent an excellent alternative to traditional ones. They provide excellent precision, speed and exposure of the operative field, while at the same time being significantly atraumatic. Compared to traditional open surgery, they are associated with less fluid loss, earlier bowel function resumption, shortened operative time, higher cost-effectiveness and faster hospital recovery. Nowadays, the mini-invasive techniques should be an indispensable part of the vascular surgeon's arsenal in the treatment of vascular diseases.

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