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Robotic Operations in the Field of Vascular Surgery

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Robotic Vascular Surgery is not yet approved by the FDA

Why?

The da Vinci Surgical System

The idea of surgical robotics was little more than a curiosity until 1999, the year Intuitive Surgical introduced the da Vinci® Surgical System.

- Computer-enhanced telemanipulator
- May help to overcome some of the limitations of traditional laparoscopic instruments
- Developed for military surgeons (at the frontline, out at see, space flights)



The da Vinci Surgical System

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Da Vinci has been used in a variety of surgical disciplines

The use of robots in vascular surgery

is still relatively unique

The da Vinci Surgical System

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The da Vinci system was installed at our institution in October 2005.

Previous experience:

56 totally laparoscopic aortoiliac reconstruction



Robotic vascular procedures

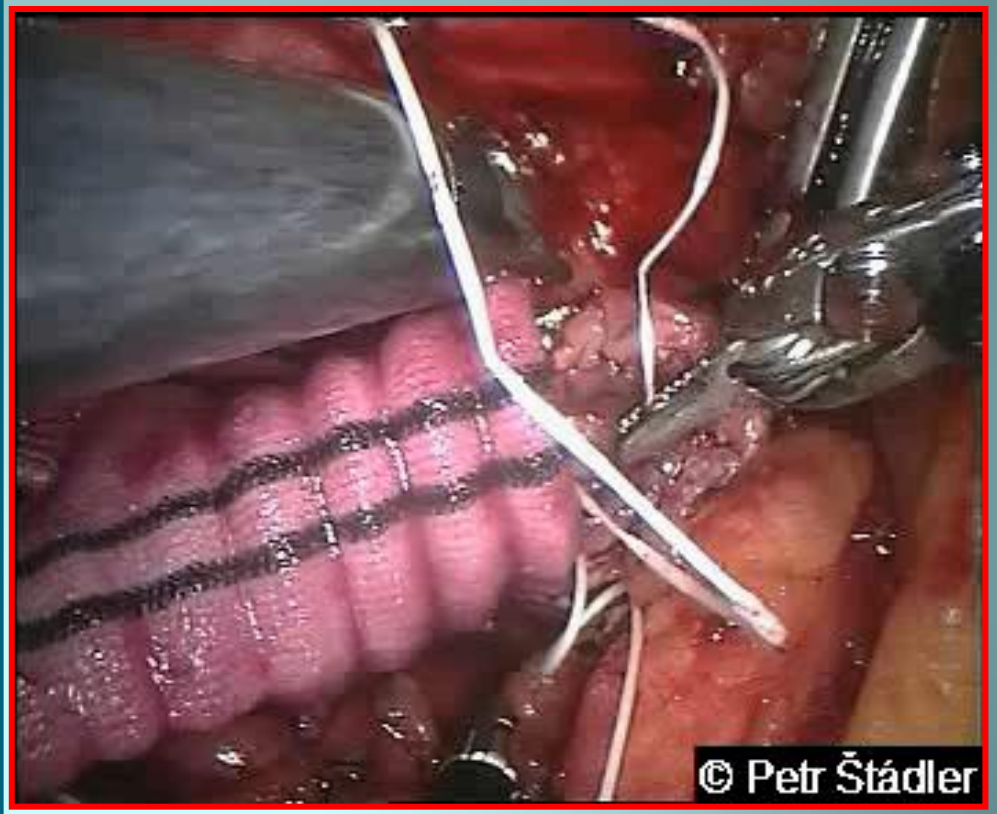
November 2005 – December 2013 TOTAL: 300

MOST FREQUENT:

1. IFB (iliofemoral bypass)
2. AUFB (aortounifemoral b.)
3. ABFB (aortobifemoral b.)
4. AAA

LESS FREQUENT:

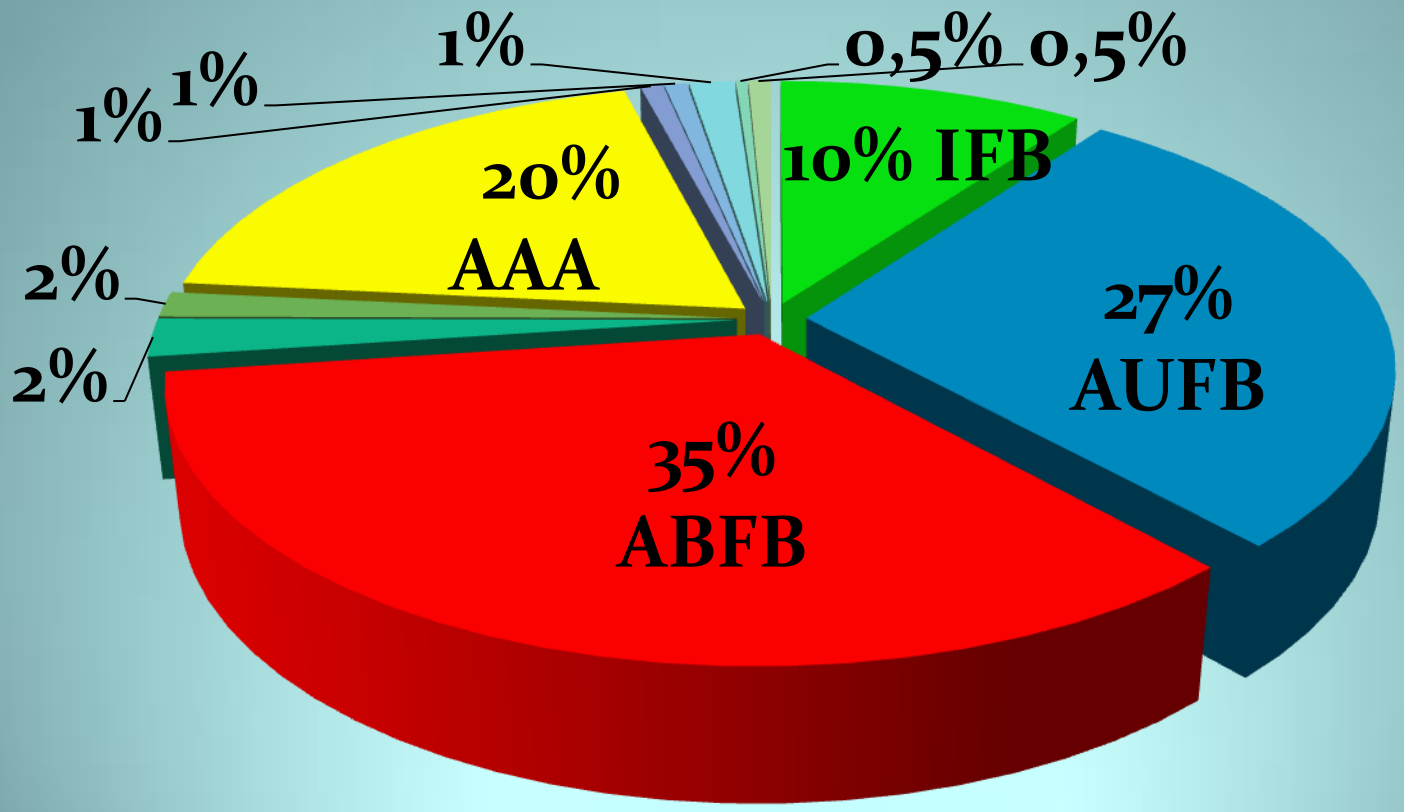
5. AIE (aortoiliac thrombendarterectomy + patch)
6. CIAA (common iliac artery aneurysm – tube graft)
7. SAA (splenic artery aneurysm)
8. Ilio(aorto)renal bypass
9. Endoleak II. (post EVAR)
10. Mammary artery aneurysm
11. Coeliac trunk deliberation
12. Hybrid procedures



The central anastomosis (End to end) of the ABFB.

The most / less frequent operations

92 / 8%



AAA abdominal aortic aneurysm **AUFB** aortounifemoral bypass **ABFB** aortobifemoral b.

Patient´s positioning and position of trocars



- Right side at a 30-45°
- Mild Trendelenburg p. (10-15°)
- The left arm alongside the body
- Six 11-12mm trocars

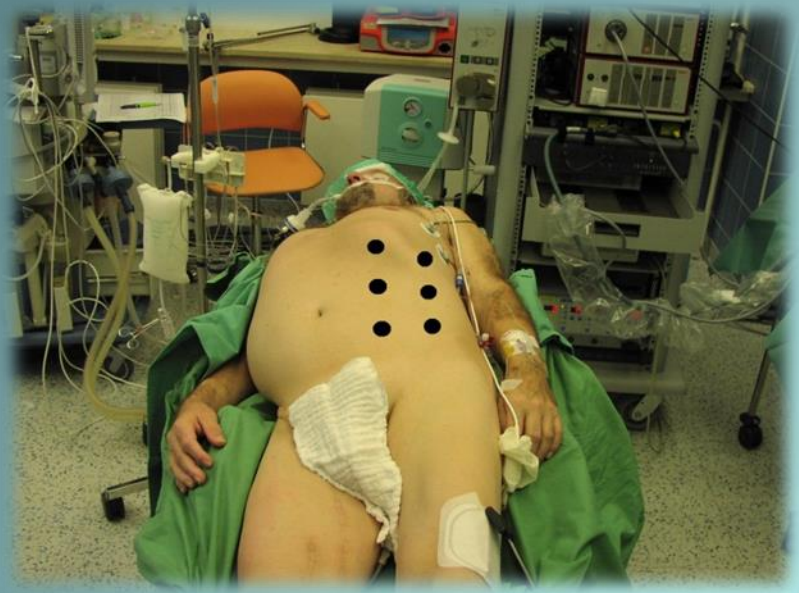
The position of the trocars differs from that used in conventional vascular laparoscopy.

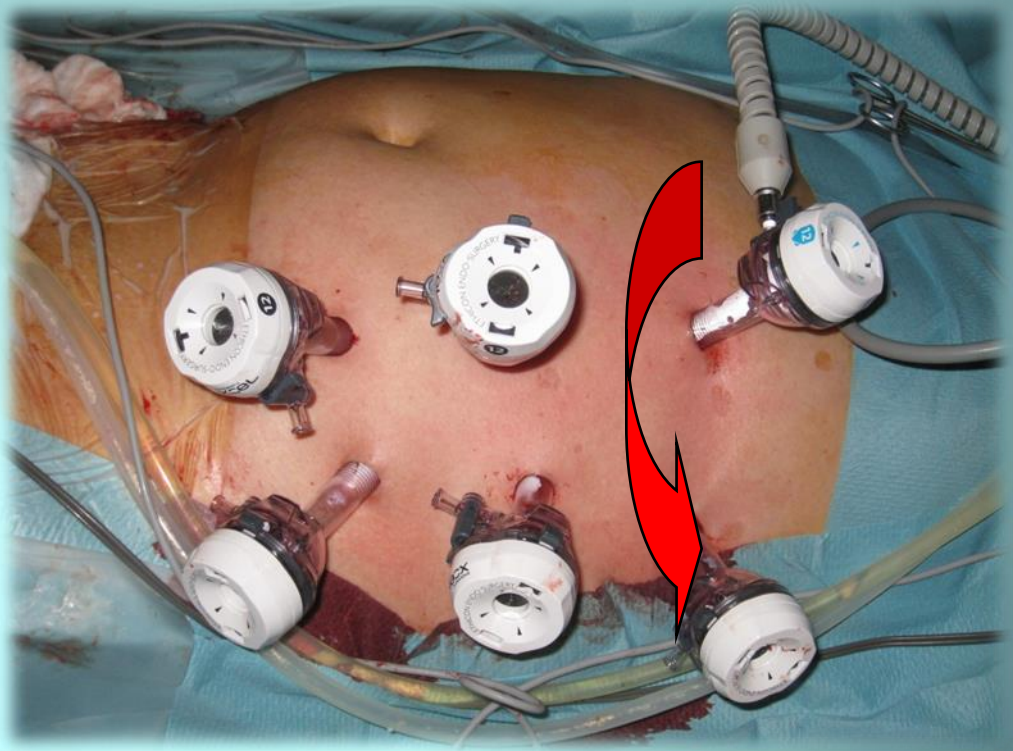
The robotic system is ready for use on the patient´s right side.

1. prox. aortic clamp, 2. and 4. robotic arms
3. robotic camera, 5. assistent´s port
6. distal aortic clamp

Position of trocars - innovation

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Approach

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CLINICAL RESEARCH STUD

Robot-assisted aortoiliac reconstructio of 30 cases

Petr Štádler, MD,[a] Pavel Matouš, MD,[a] Petr Vitásek, MD,[a] and Miroslav Špač
Republic

Objective: The feasibility of laparoscopic aortic surgery with robotic assistance has b
Reported is the clinical experience of robot-assisted aortoiliac reconstruction for o
performed using the da Vinci system.
Methods: Between November 2005 and June 2006, 30 robot-assisted laparoscopic aortoili
Twenty-seven patients were prospectively evaluated for occlusive disease, two patients fi
and one for common iliac artery aneurysm. Dissections of the aorta and iliac arteries w
using a transperitoneal direct approach technique, a modification of the Štádler method.
construct anastomoses, to perform thromboendarterectomies and, in most of the cases, fo
Results: Robot-assisted procedures were successfully performed in all patients. The robo
abdominal aortic and common iliac artery aneurysm anastomoses, the aortoiliac reco
complete the central, end-to-side anastomosis in another operation. Median operating tir
to 360 minutes), with a median clamp time of 54 minutes (range, 40 to 120 minutes).
time elapsed from the initial incision to final skin closure. Median anastomosis time wa
minutes), and median blood loss was 320 mL (range, 100 to 1500 mL). No conversion wa
100%, median intensive care unit stay was 1.8 days, and median hospital stay was 5.3 days.
after a mean time of 2.5 days.
Conclusion: Robot-assisted laparoscopic surgery is a feasible technique for aortoiliac surge
facilitated the creation of the aortic anastomosis and shortened aortic clamp time in con
techniques. (J Vasc Surg 2006;44:915-9.)

Vascular surgical technology has evolved progressively, and a number of reports from centers around the world describing different minimally invasive techniques have been published. Total laparoscopic aortoiliac surgery can be performed on patients with occlusive diseases and aneurysms.[1,2] After completing total laparoscopic aortoiliac procedures in 56 patients from September 2003 to November 2005, we began performing robot-assisted aortoiliac reconstruction. This article presents data for the first 30 robot-assisted cases. The purpose of our study was to evaluate the clinical outcome, results, and the applicability of the da Vinci Surgical System (Intuitive Surgical Inc., Sunnyvale, CA) system for vascular surgery.

The da Vinci Surgical System is a computer-enhanced telemanipulator that may help overcome some of the limitations of traditional laparoscopic instruments. Intuitive

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Competition of Interest: none.
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doi:10.1016/j.jvs.2006.07.045

Surgical developed the da Pentagon, where a meth surgeons to perform rem for them to be at the fro

The technical difficul cular anastomosis using l a major drawback, and solution to this problem. technology translates the cise, real-time movement patient.[5] Robotic surger quires smaller incisions in open procedure.

MATERIAL AND ME

Patients. From Nov robot-assisted aortoiliac r our institution. They incl terectomies with prosthe aortounifemoral, and 10 tients were treated for ab for common iliac artery a included 23 men and 7 years (range, 43 to 78 ye

Eur J Vasc Endovasc Surg (2008) 36, 401–404

ELSEVIER



Is Robotic Surgery Appropriate for Vascular Procedures? Report of 100 Aortoiliac Cases

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Available online 21 August 2008

KEYWORDS
da Vinci System;
Robot-assisted aortoiliac reconstruction;
Arterial occlusive disease;
Common iliac artery aneurysm

Abstract *Aim:* The aim of our study was to evaluate our clinical experience of the da Vinci™ system for robot-assisted aortoiliac reconstructions to treat occlusive disease and aneurysm.
Material and methods: Between November 2005 and January 2008 100 consecutive patients were scheduled to undergo robot-assisted laparoscopic aortoiliac procedures. Patients with serious medical problems and those who had previously undergone major abdominal surgery were excluded from the clinical study. Ninety patients were prospectively evaluated for arterial occlusive disease (AOD), seven patients for abdominal aortic aneurysms (AAA), two for common iliac artery aneurysms (CIAA) and one for a combination of CIAA and AOD.
Results: Ninety-seven of 100 procedures (97%) were successfully completed robotically, while conversions were necessary in three patients (3%). The median operating time was 235 minutes (range 150 to 360 minutes), with a median clamp-time of 42 minutes (range 25 to 120 minutes). The median anastomosis time was 29 minutes (range 12 to 60 minutes) and median blood loss was 430 mL (range 50 to 1500 mL). The median intensive care unit stay was 1.7 days and the median hospital stay was 5.1 days. A regular oral diet was resumed after a mean of 2.4 days. Thirty-day survival was 100% and non-lethal postoperative complications were observed in three patients (3%).
Conclusions: Robotic aortoiliac surgery appears to be safe, with a high technical success rate, with operative times and success rates comparable to conventional open surgery. The creation of the aortoiliac anastomosis appears to be quicker, and more accurate than regular laparoscopic techniques.
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Introduction

Major developments in laparoscopic surgery in the 1990s have had a delayed impact on vascular surgery. Minimally invasive approaches used in general surgery have gradually been introduced as novel techniques that can be employed in vascular surgery.[1] The main reasons for this initial lack of interest in laparoscopic vascular surgery were the difficulties associated with the suturing of the vascular anastomosis and the long clamping time. These same reasons have also prevented the further expansion of vascular laparoscopy. Robotics, which was first introduced in 2000, is

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SHORT REPORT

echnique of Transperitoneal Direct Approach tally Laparoscopic Aortoiliac Surgery

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f Vascular Surgery, Na Homolce Hospital, Praha, Czech Republic

lification of the transperitoneal direct approach (TDA) for totally laparoscopic aortoiliac
ptember 2003 to August 2005 a total of 52 patients underwent laparoscopic operations for occlusive disease; two abdominal aortic aneurysm). The modified TDA was used in 20
ge of TDA is reduced dissection of the aorta and pelvic arteries resulting in lowered blood
surgery; Total laparoscopic aortoiliac surgery; Modification of transperitoneal direct

n

scopic surgery in the on vascular surgery. used in general sur- novel technique used 93, Dion performed ortobifemoral bypass opic abdominal aortic was performed.[3] At oach is used for vas- of the main advan- educed pain, shorter turn to regular daily their experience with bypass surgery and oneal direct approach ire was offered to 20

Material and Methods

From September 2003 to August 2005, 52 laparoscopic operations of the abdominal aorta and iliac arteries were performed at our institution. They included 16 iliofemoral (IFB), 17 aortounifemoral (AUFB) and 15 aortobifemoral bypasses (ABFB); two aortoiliac thrombendarterectomies (TEA), and two AAA resections (Fig. 1(A) and (B)). Patients with significant medical problems, morbid obesity and previous major abdominal surgery were excluded from the clinical study. Disease was classified in accordance with the American Society of Anesthesiologists (ASA) classification. Patients with ASA IV–V, significantly abnormal cardiac, pulmonary, hepatic and renal test results were not offered a laparoscopic procedure. Preoperative data are summarized in the Table (Fig. 1(C)). The laparoscopic transperitoneal approach was used in all IFB and five AUFB. Eleven patients underwent the transperitoneo-retroperitoneal approach (TRA) described by Dion and the modified TDA was offered to 20 patients.

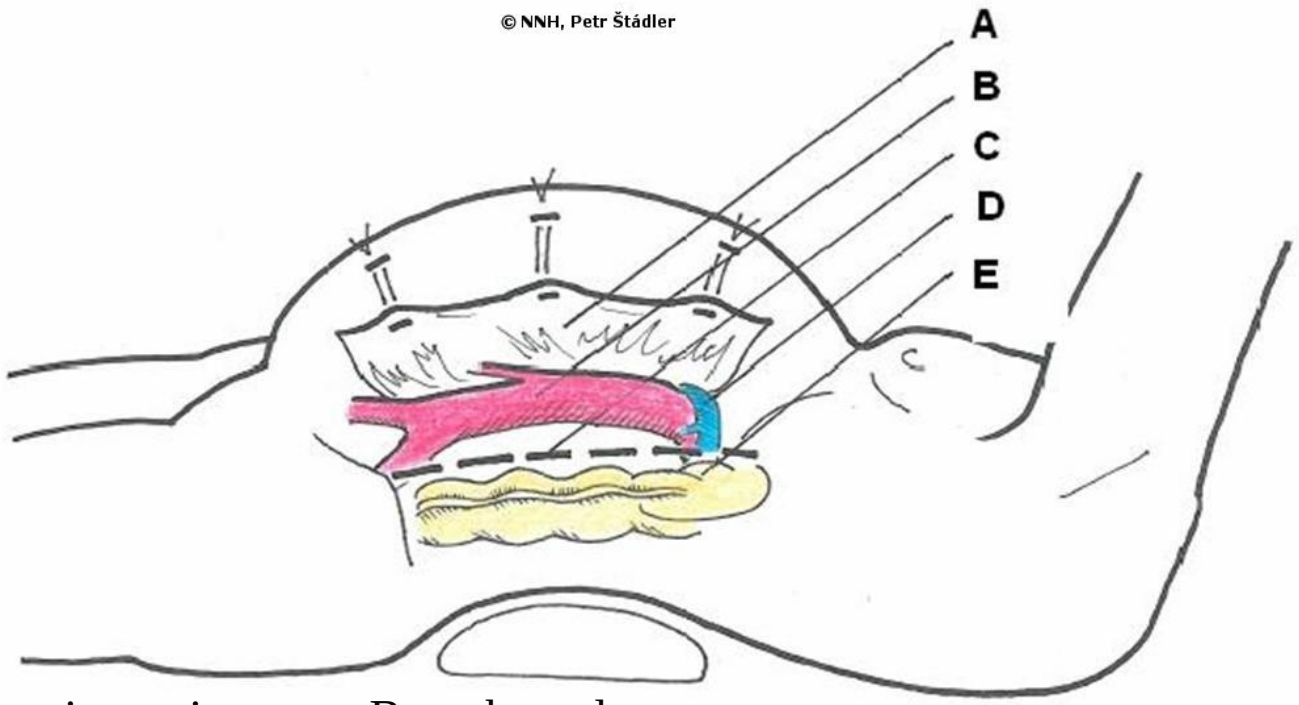
Operative technique

The patient was placed on their right side (except for the right IFB) at a 45° angle and in mild

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Position of colon and exposure of infrarenal aorta



A - fixed posterior peritoneum, B - subrenal aorta,

C - line for opening the posterior peritoneum,

D - left renal vein, E - descending colon

Robot-assisted vascular operations

Two steps

Laparoscopic activity

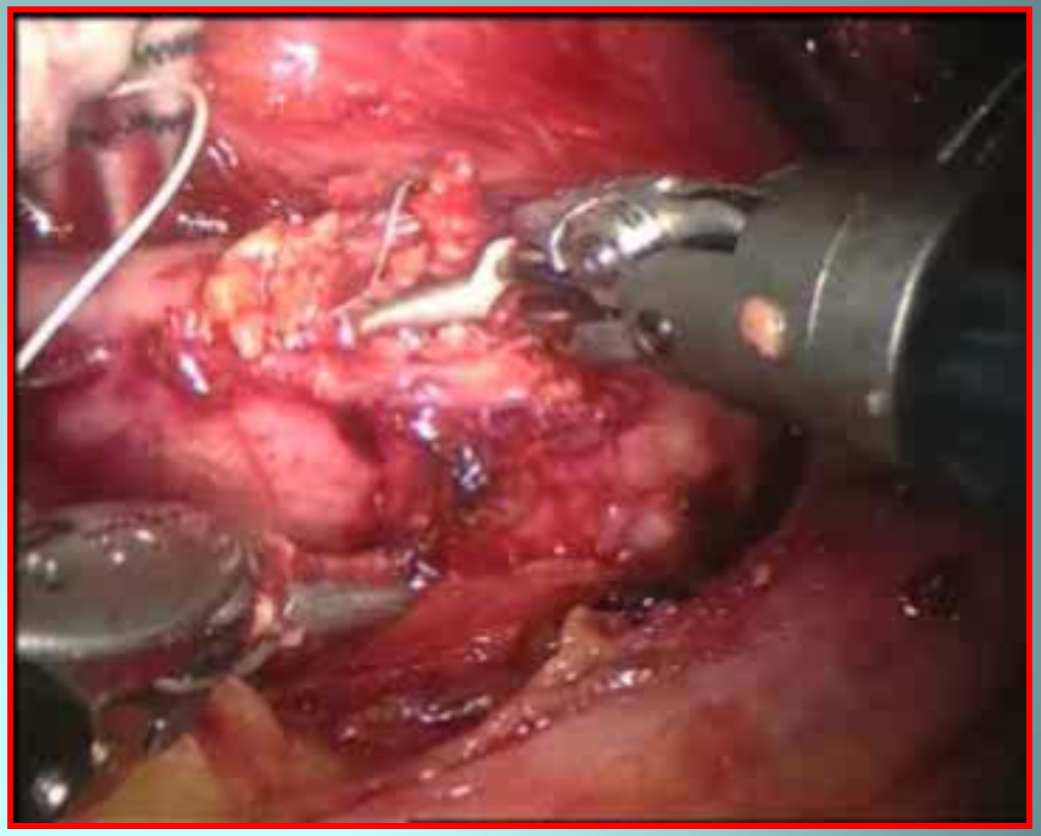
and

Robotic activity

OR

One step only

Full robotic activity



Removing of abdominal aortic stent before anastomosis

Robot-assisted vascular procedures

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THE LAPAROSCOPIC PART

- The small bowel and the omentum are moved to the right side of the abdomen
- The posterior peritoneum is opened on the left aortic side alongside the gonadal vein
- The posterior peritoneum with preaortic fat and ganglia is separated and moved to the right aortic wall.





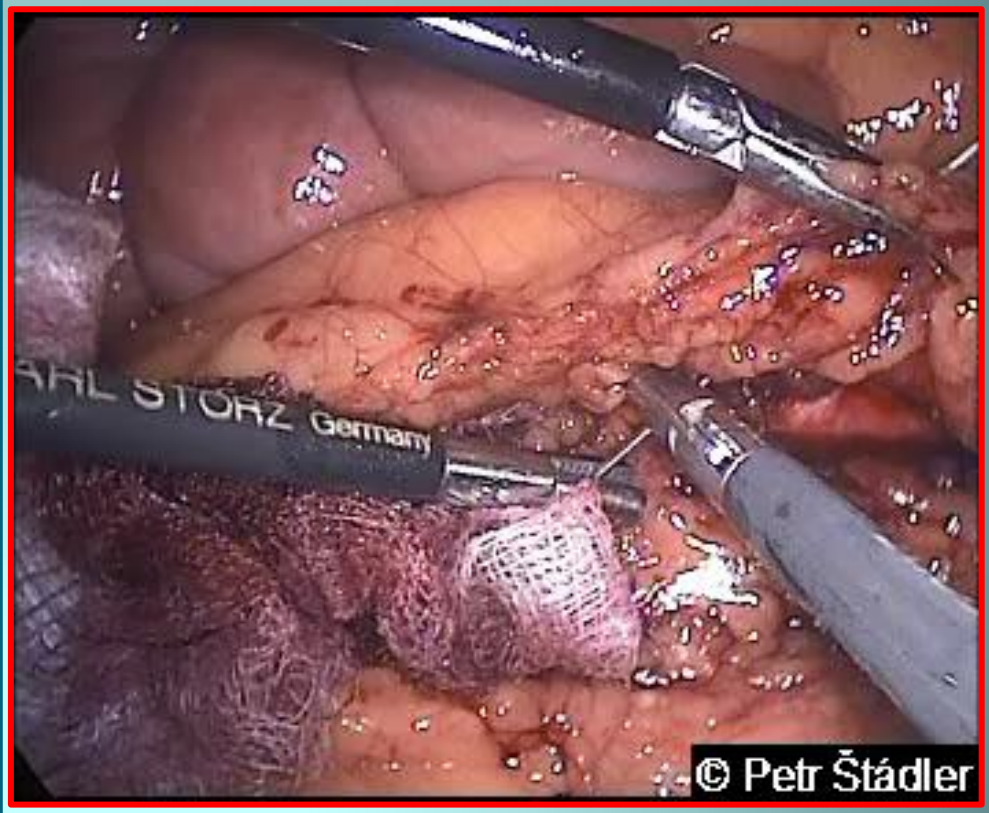


Robot-assisted vascular procedures

THE LAPAROSCOPIC PART

- The posterior peritoneum
  is stitched to the abdominal wall using several sutures

- The barrier construction
  does not require mobilisation of the descending colon.

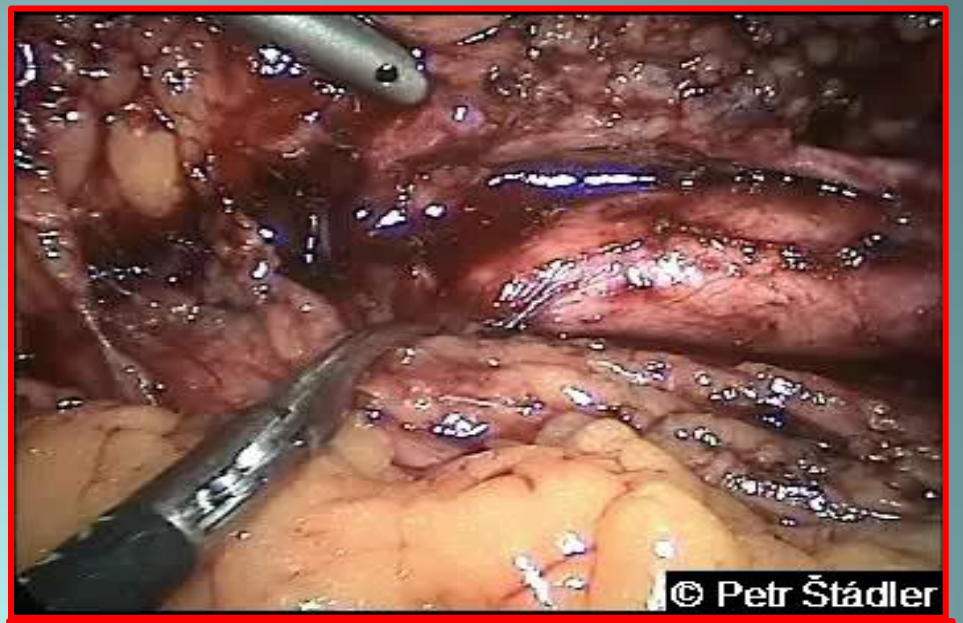


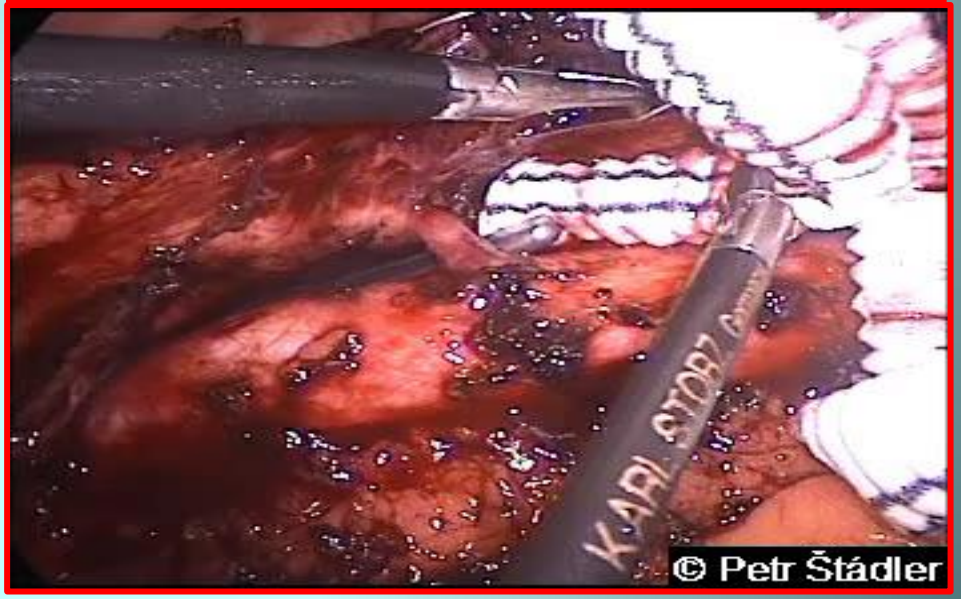
Robot-assisted vascular procedures

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THE LAPAROSCOPIC PART

- Tunneling is performed from one or two groins under the direct view of the camera using a long Debakey aortic vascular clamps.
- The vascular prothesis with an attached shortened stitch is inserted into the abdomen.
- The limbs of the graft are moved to the femoral regions using the installed vascular clamps.





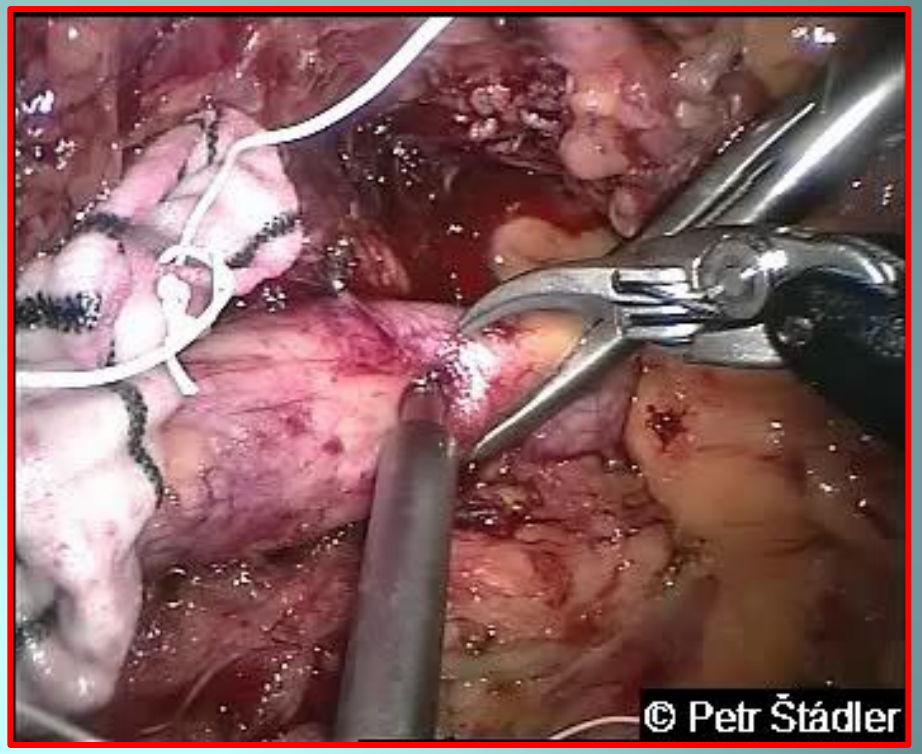
Robot-assisted vascular procedures

THE ROBOTIC PART

- Aortotomy

or arteriotomy by robotic scissors usually represents the start of the Robotic system in the case of combination laparoscopic and robotic vascular procedure

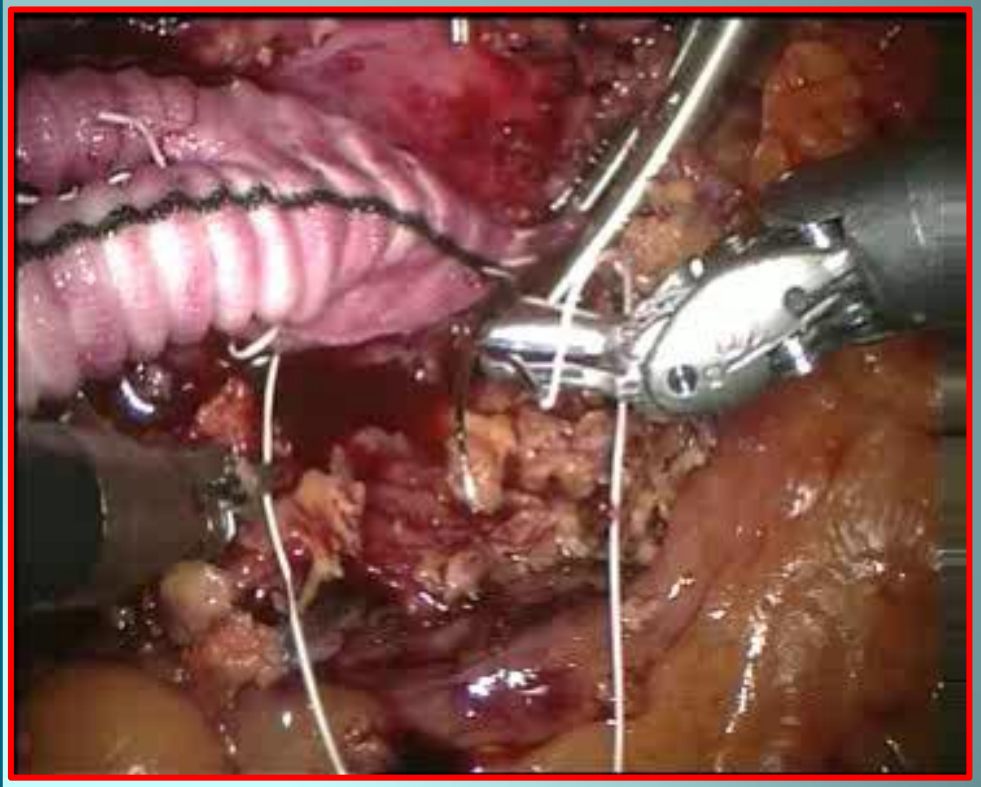
It is sometimes followed by a post arterial puncture with an endoscopic knife.



Robot-assisted vascular procedures

THE ROBOTIC PART

- Construction of the intraabdominal anastomosis represents the most important utilisation of da Vinci system. Robot-assisted vascular anastomosis can be performed quickly and efficiently resulting in a significantly shorter clamping time



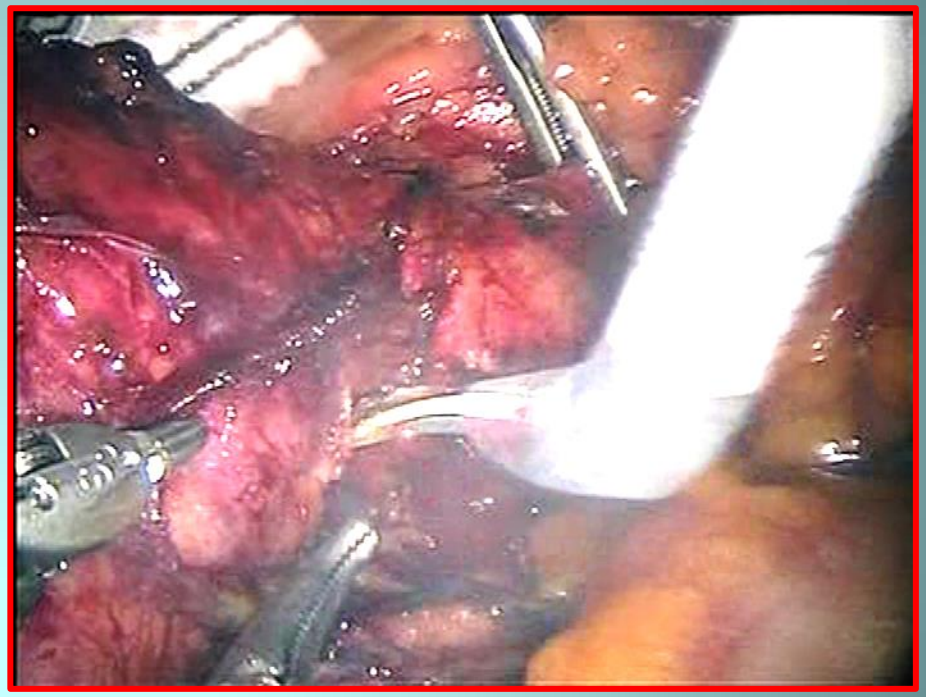
The central anastomosis of the ABFB (End to side)

Robot-assisted vascular procedures

We use the Robot for different parts of vascular surgery.

- Aortotomy

by robotic scissors (AAA)



Robot-assisted vascular procedures

- Thrombendarterectomy

Aortoiliac thromboendarterectomy with a prosthetic patch is another interesting application of the robot in vascular surgery.



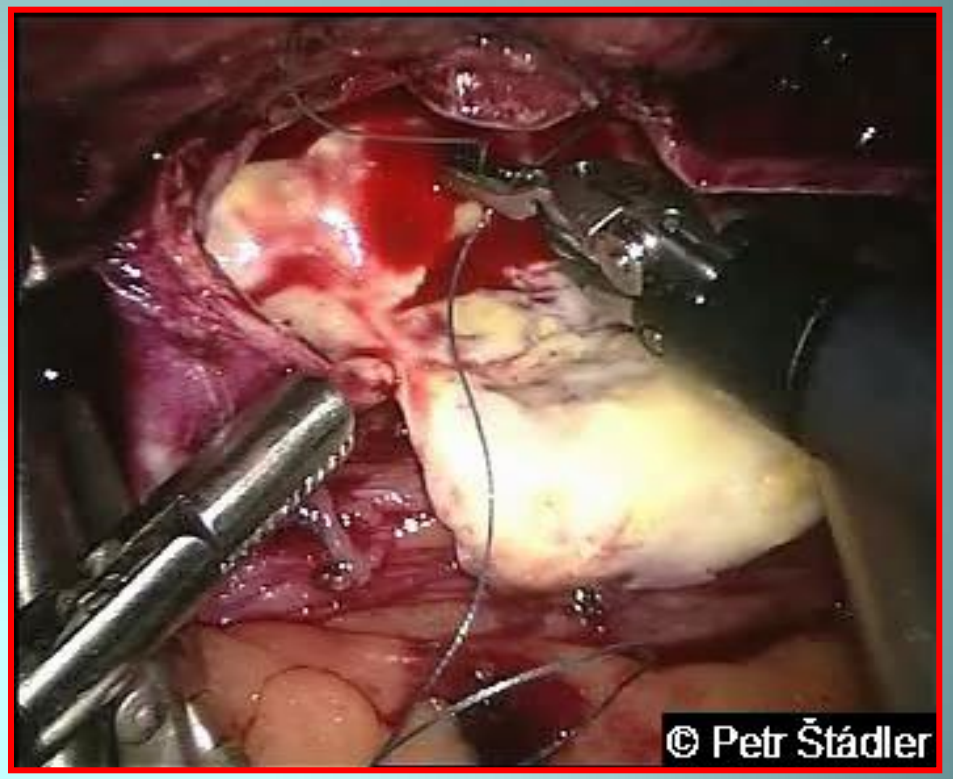


Robot-assisted vascular procedures

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- Hemorrhage control of the remaining lumbar arteries after opening of the aneurysmal sac.

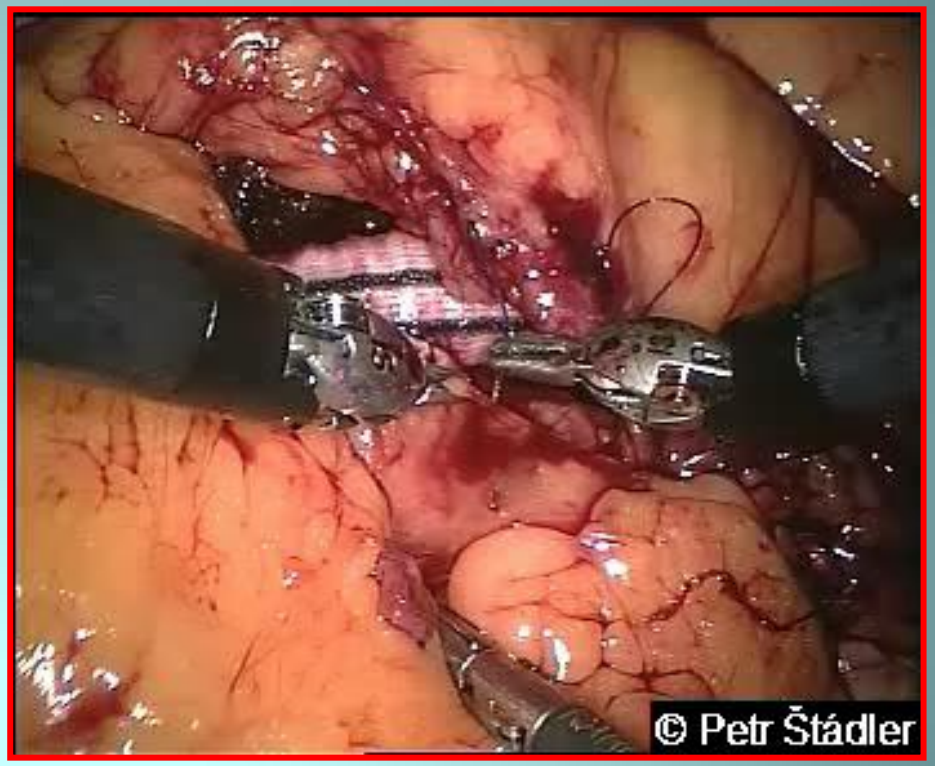
For AAA surgery, the Robotic technique is used to internally control the remaining lumbar arteries after opening the aneurysmal sac using free shortened stitches.



Robot-assisted vascular procedures

- Posterior peritoneal suture

We also use the Robotic system usually for posterior peritoneal suturing.



Robot-assisted vascular procedures

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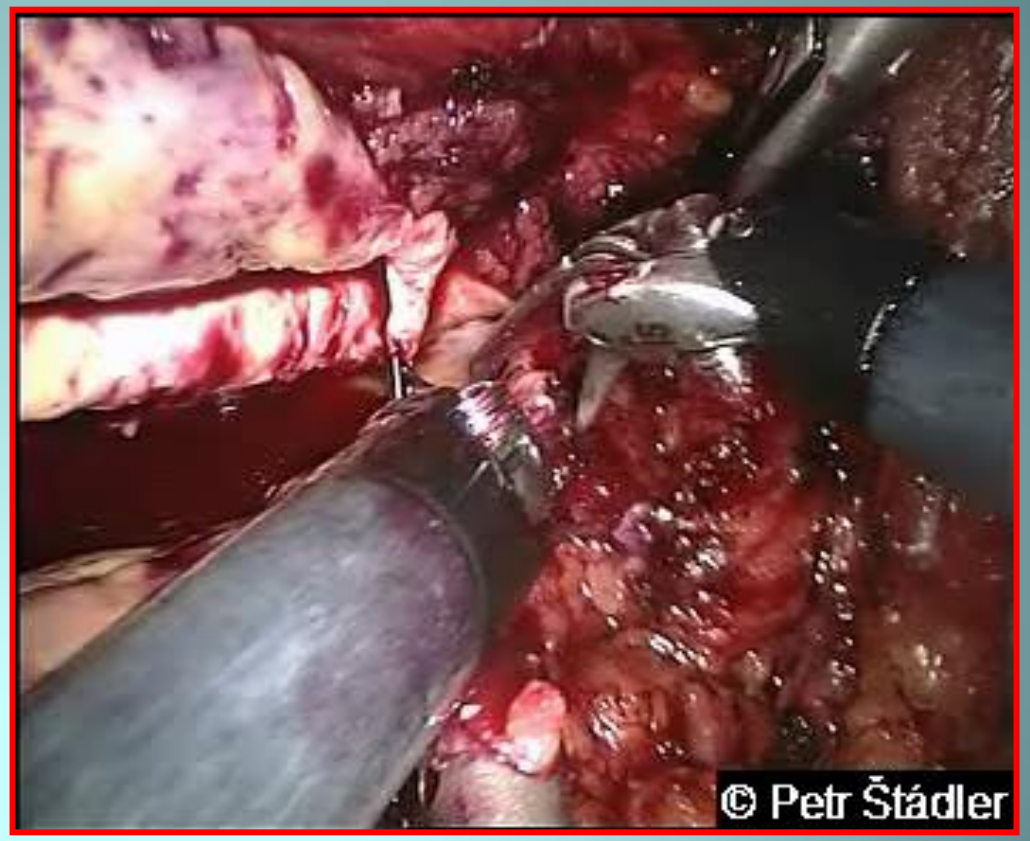
Our experiences with full robotic operations

> 50% cases



Patients characteristics

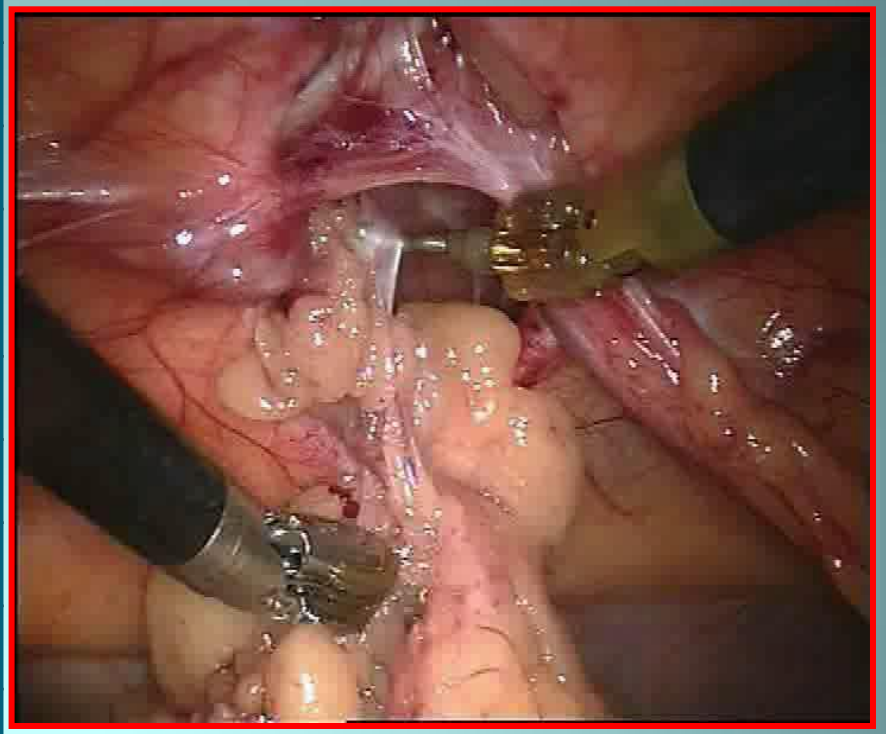
Patients	300
Men : Women	3 : 1
Age (y)	63 (38-79)
Weight (kg)	77 (45-140)
COPD	77%
CAD	27%
Hypertension	33%
Diabetes	11%



Abdominal aortic aneurysmal neck preparation by robotic scissors.

Robot-assisted vascular surgery

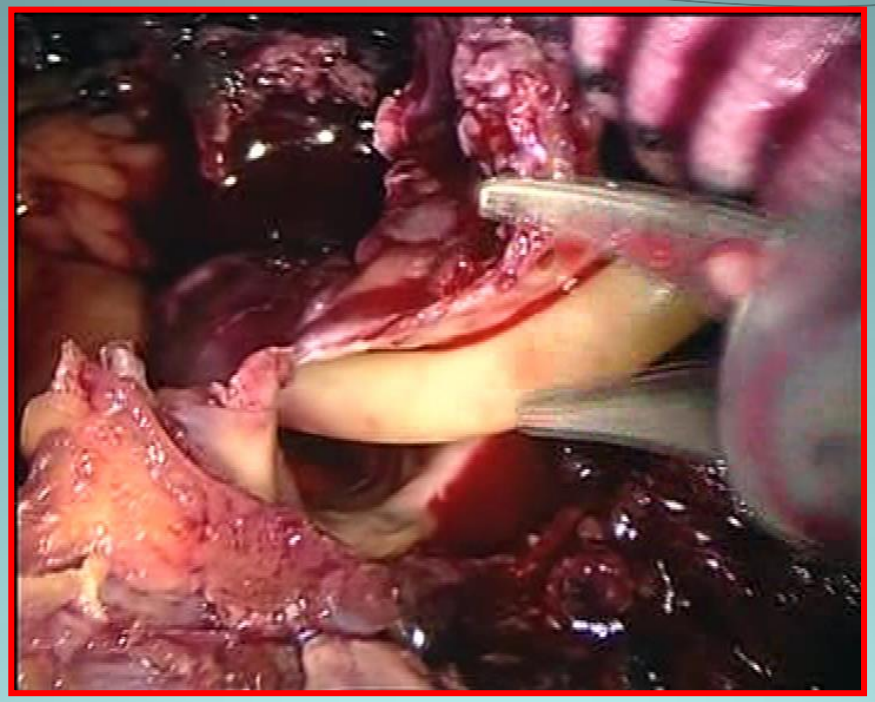
Clamping time (min)	49 (21-120)
Anastomosis time (min)	30 (12-36)
Operating time (min)	204 (150-360)
Blood Boss (ml)	571 (25-4000)
Conversion Technical problem (Robot)	10 (3,4%) 1 (0,3%)
Ventilator support (hrs)	7 (0-48)
ICU (days)	1.2 (1-5)
Regular diet (days)	2.5 (2-4)
Hospital stay (days)	5 (4-10)
30-Day mortality	0,3%
Secondary patency	99,6%
Prosthesis infection Inoperable	2 (0,7%) 2 (0,7%)



ABFB+hernia mesh repair

SELECTIVE DATE

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BYPASS

ANEURYSMS

CT (min)	37	CT (min)	51	CT (min)	93
AT (min)	24	AT (min)	31	AT (min)	31
OT (min)	194	OT (min)	210	OT (min)	253
BL (ml)	320	BL (ml)	570	BL (ml)	1210

Conversion 10 (3,4%)

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2x	MINI-LAPAROTOMY
7x	FULL LAPAROTOMY
1x	FEMORO-FEMORAL B. (AUF→ FF)

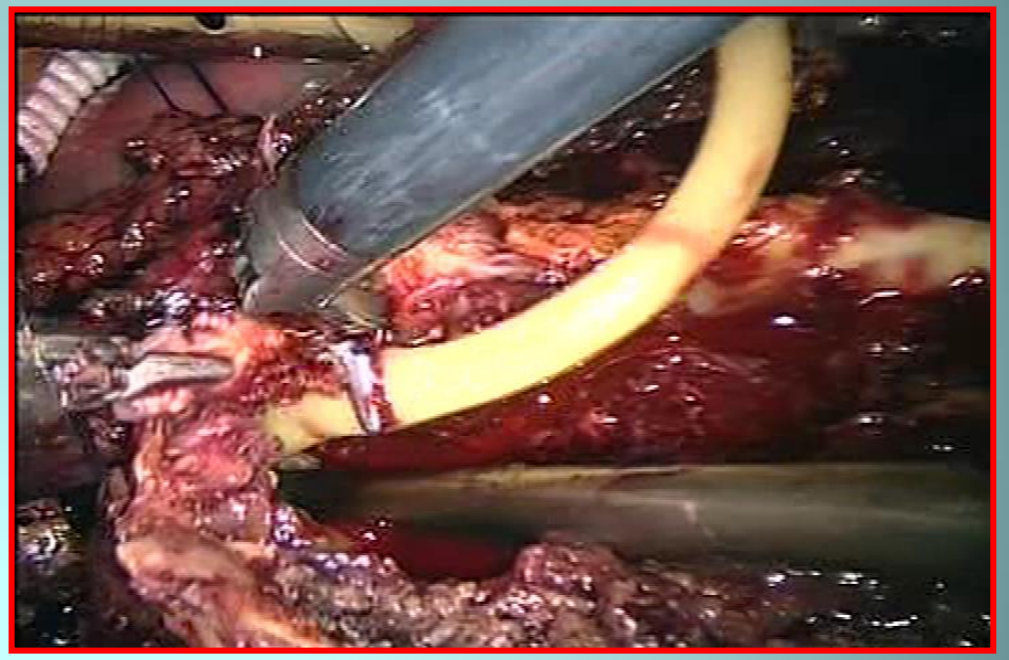


CIAA – common iliac artery aneurysm
LA – lumbar artery
LAA – lumbar arteries

Robot - advantages

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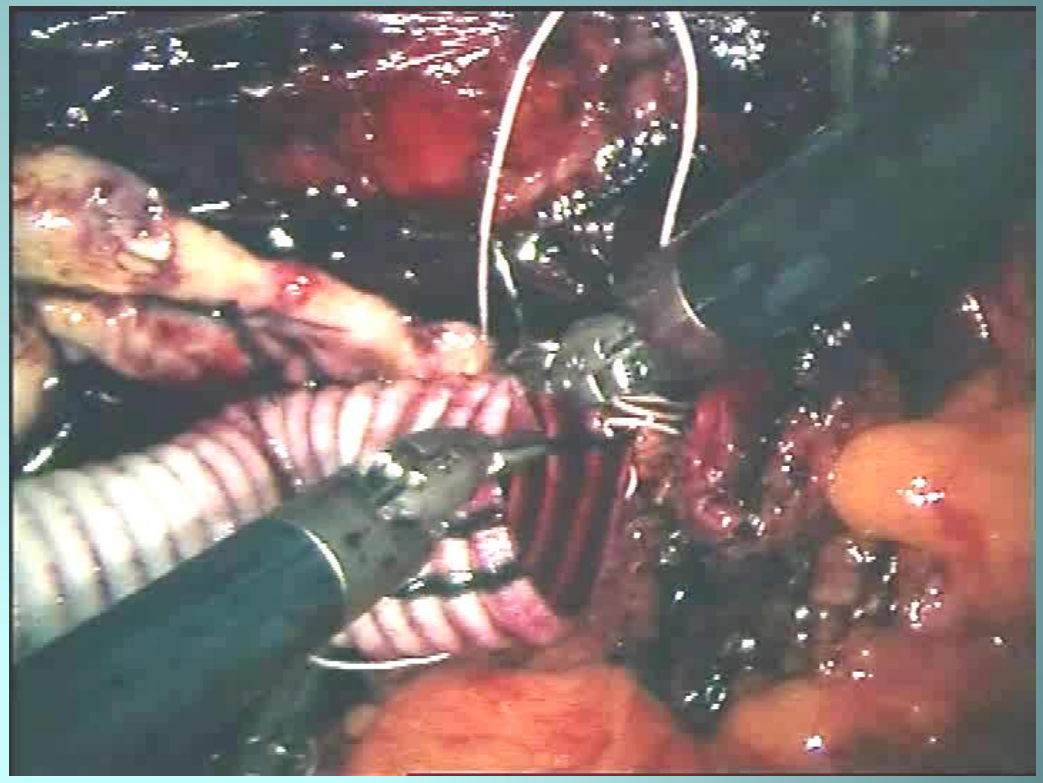
* Perfect 3D imaging
* Fine tissue manipulation (in small spaces)
* More controlled movements
* Hand tremor excluded
* Maximal flexibility of the robotic instruments
* Minimization some of the difficulties and limitations associated with conventional laparoscopy
* Significantly faster suturing of the vascular anastomosis leading to a significantly shorter clamping time
* Confortable and fast knotting



Robot - disadvantages

* High cost of the equipment and instruments
* Limitations on using robotic instruments

  (10,15 or 20 x)
* Lack of any tactile feedback
* Combination with conventional laparoscopy – some time
* Interference between the robotic arms (sporadic)



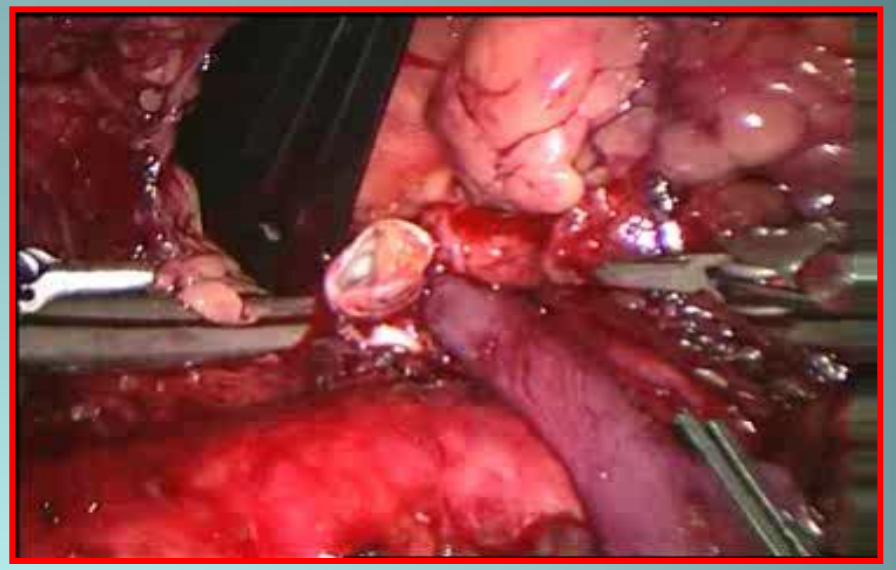
Suturing of the proximal aortic anastomosis (AAA)

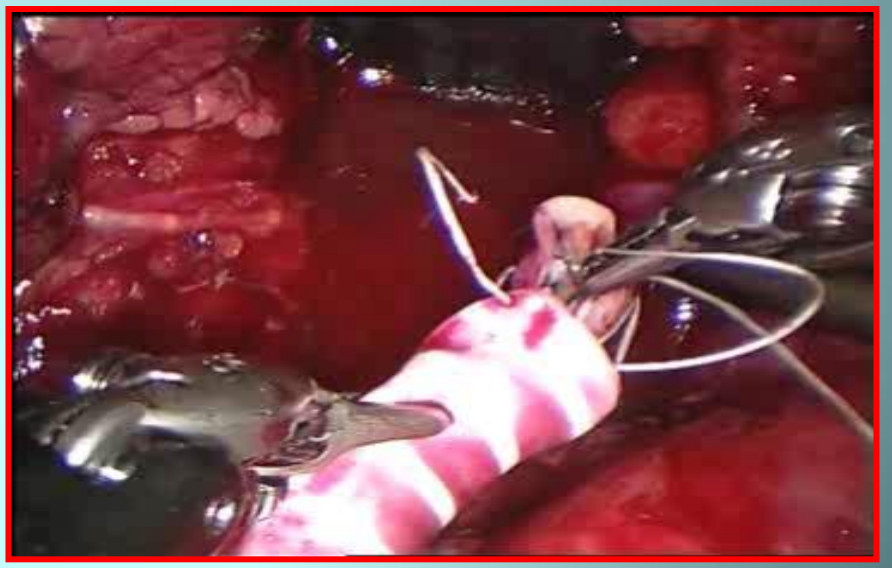
Hybrid operation

- Dissection „B“
- Women 65 y.
- Hypertension
- Stenosis a. renalis l.dx
- A. renalis l.dx. (false lumen)

TREATMENT

- Rob. as. Ilico-renal bypass (sin/dx) with endarterectomy a. renal.l.dx.
- Stentgraft (TVAR)

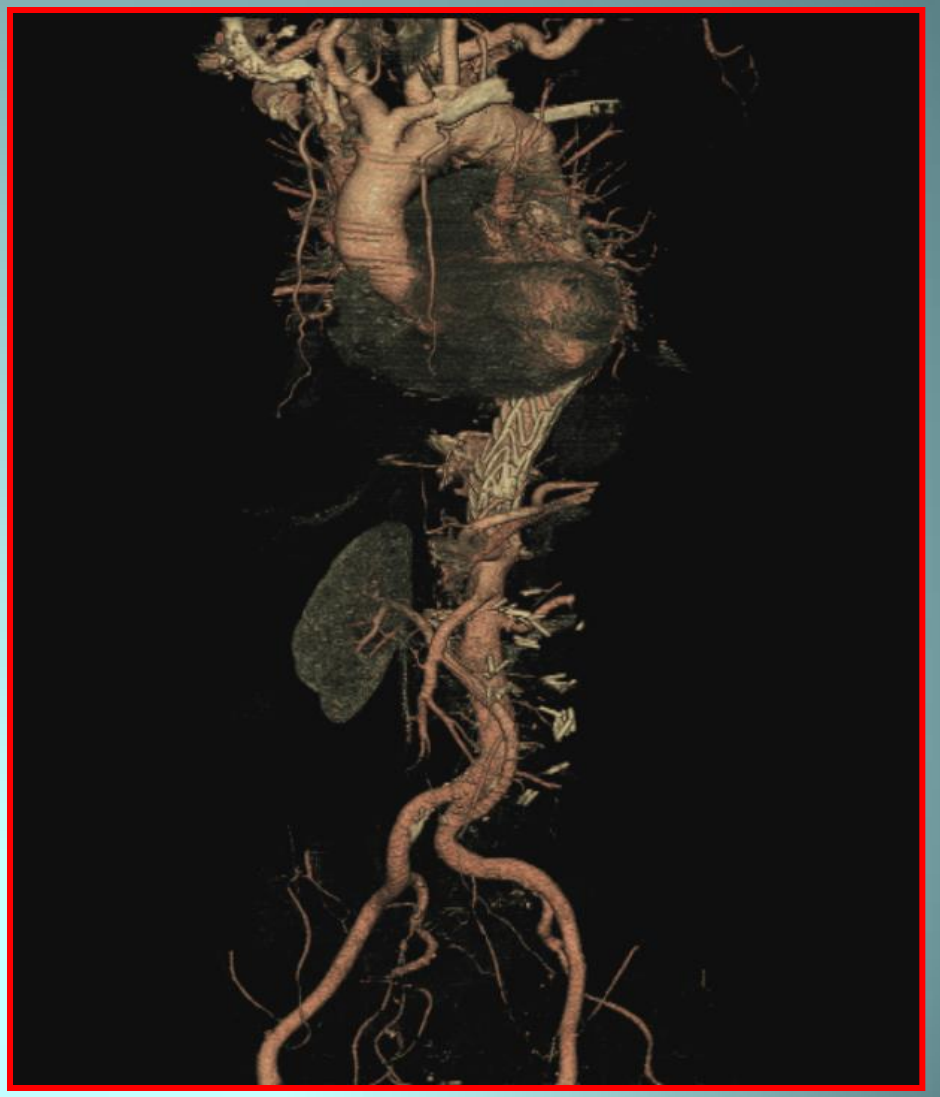




Renal tromboendarterectomy + iliorenal bypass

Hybrid operation

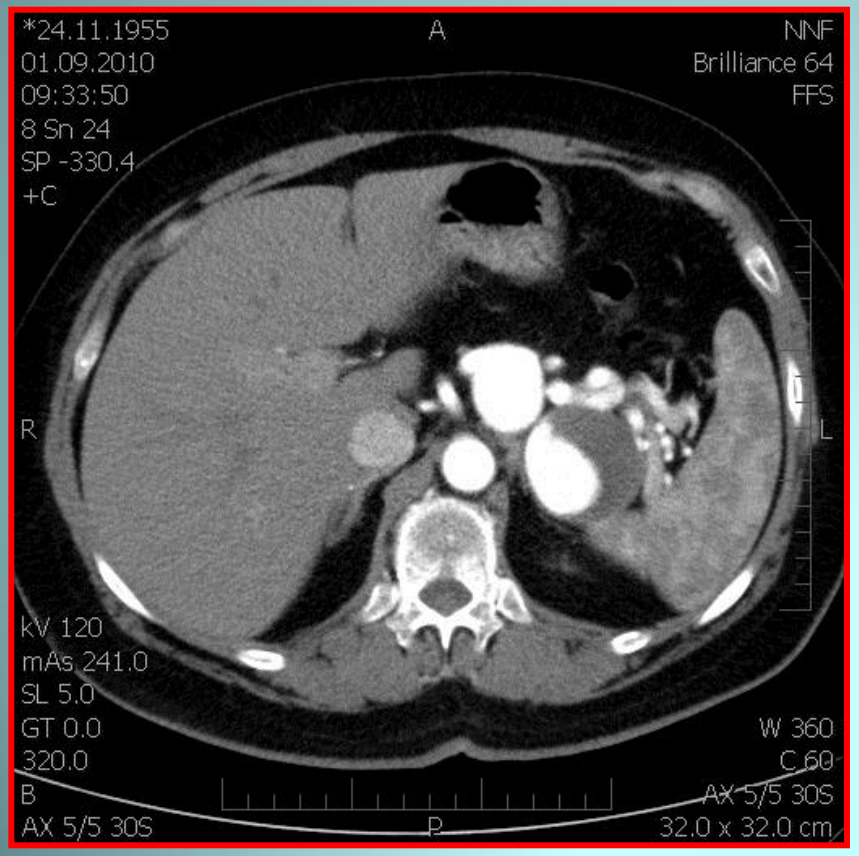


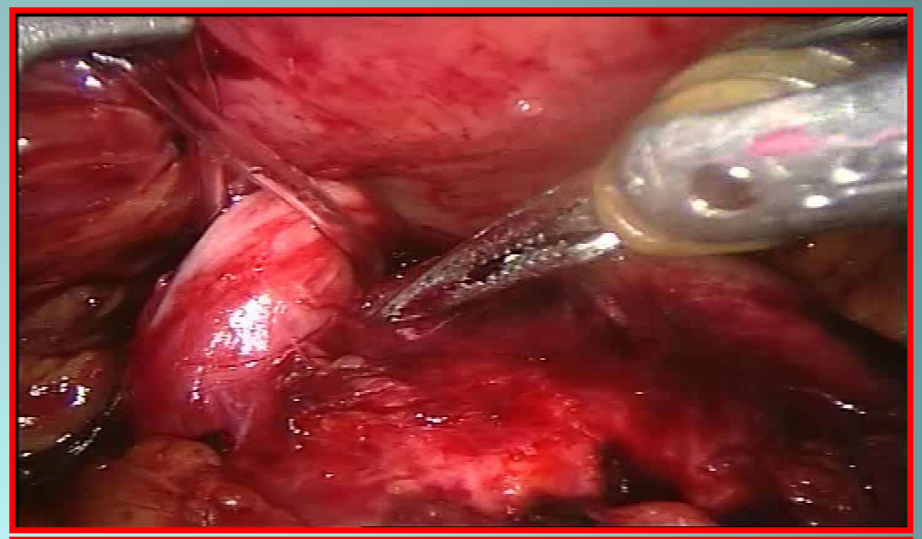


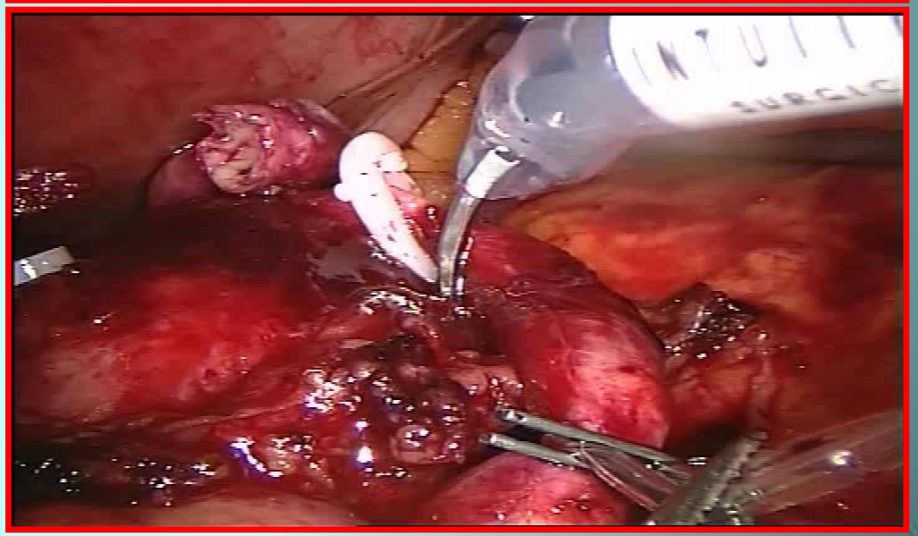
- Robotic and endovascular treatment

Robot-assisted splenic artery aneurysm treatment

Robot-assisted double splenic artery aneurysm treatment

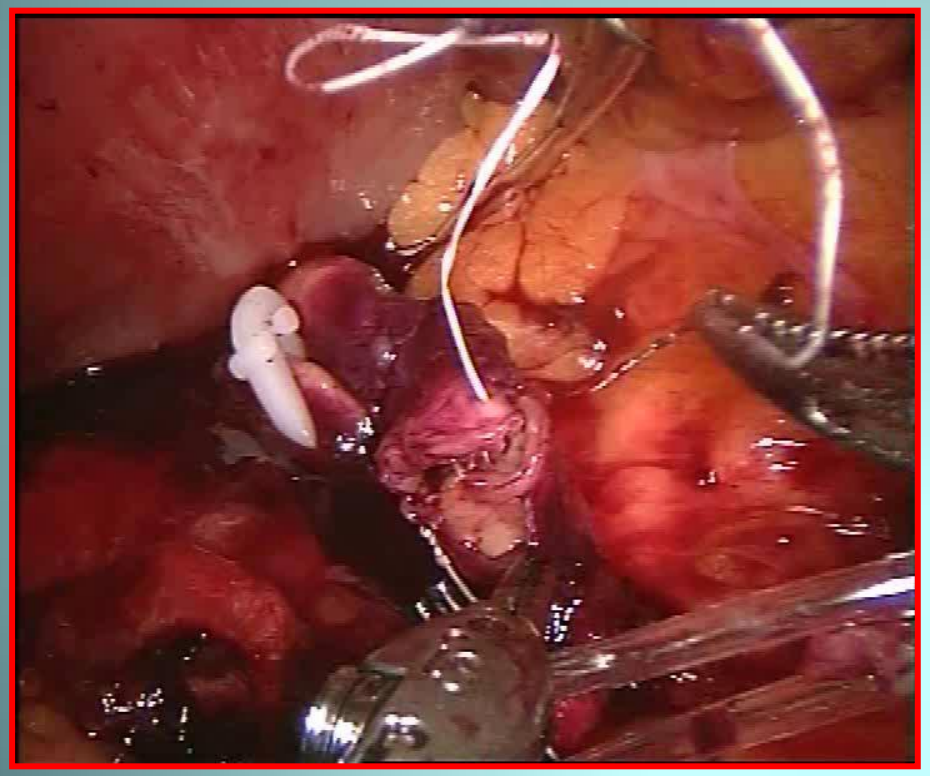


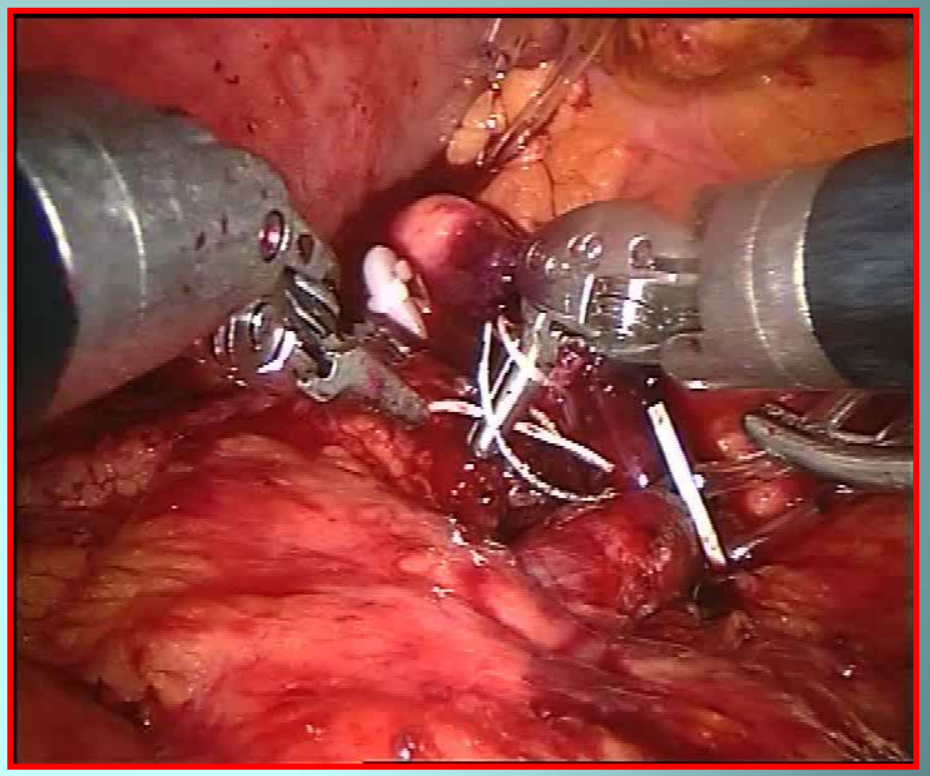




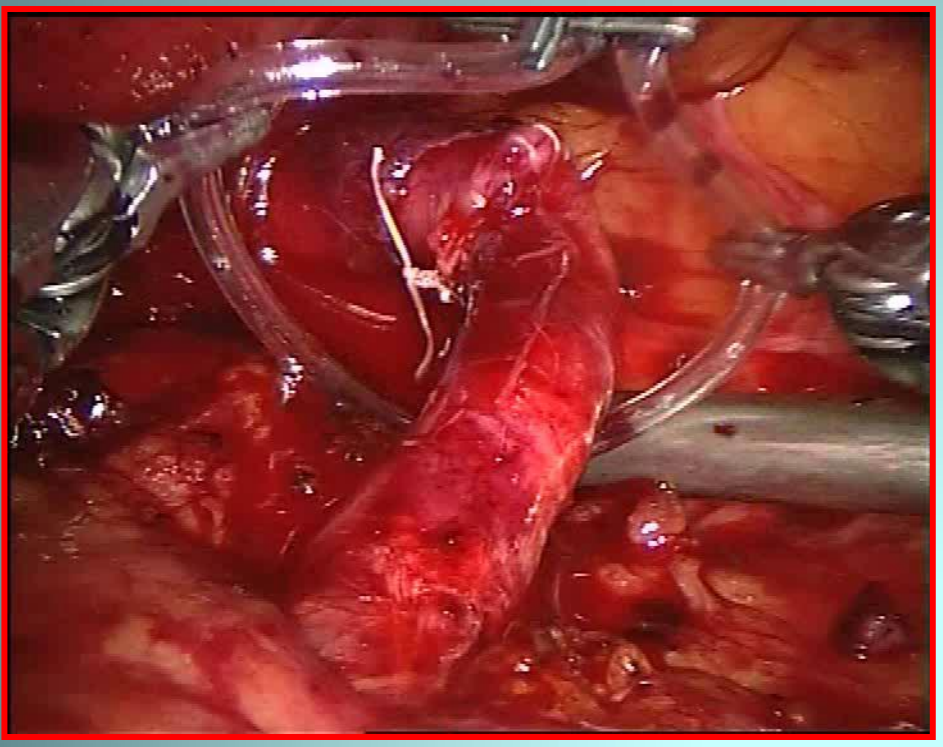
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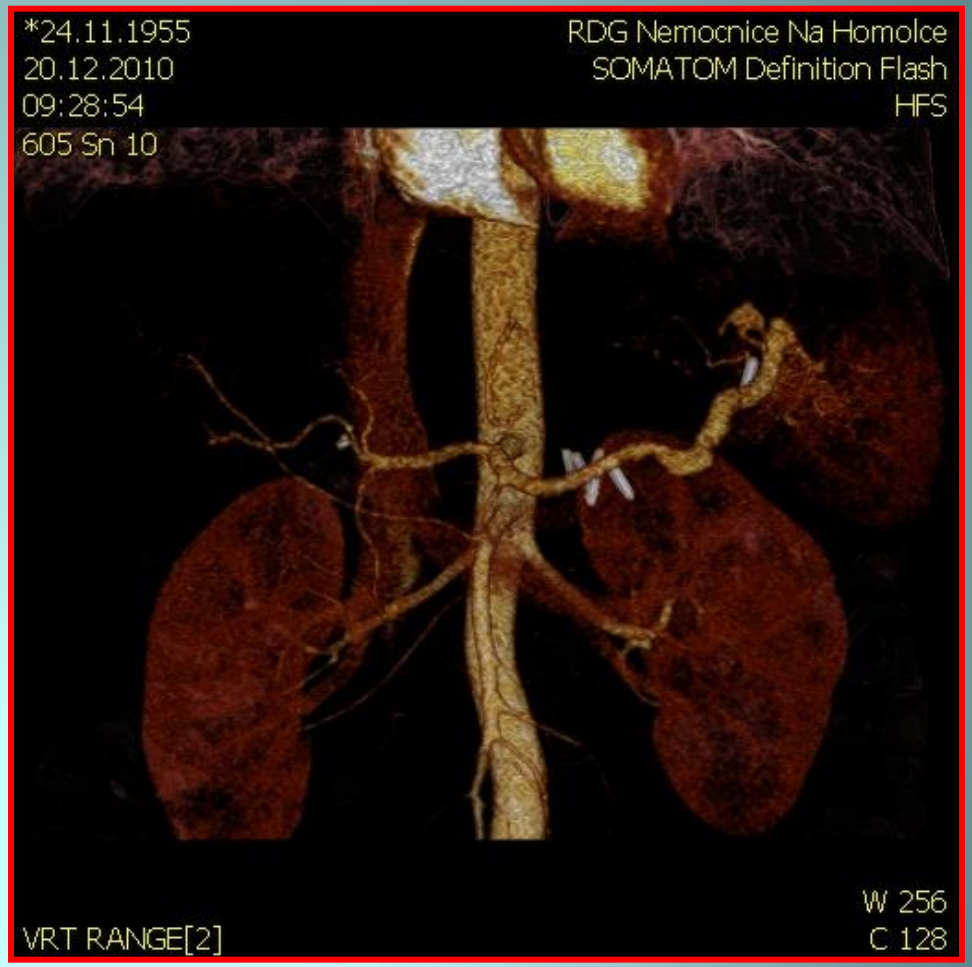
Robot-assisted splenic artery aneurysm treatment



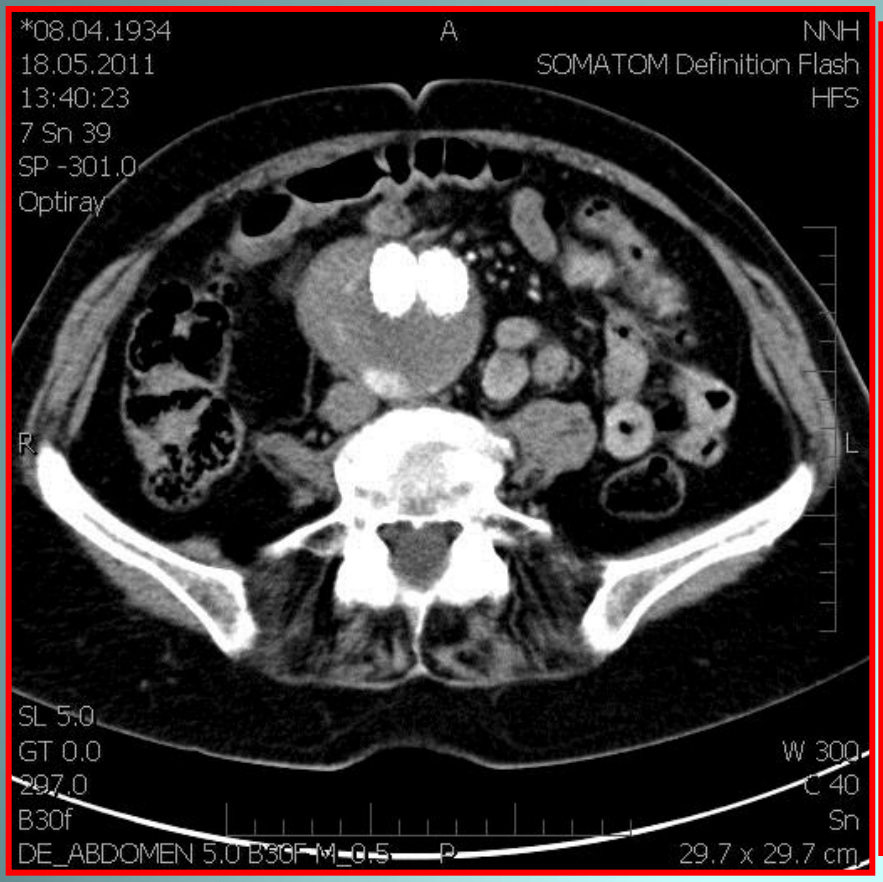


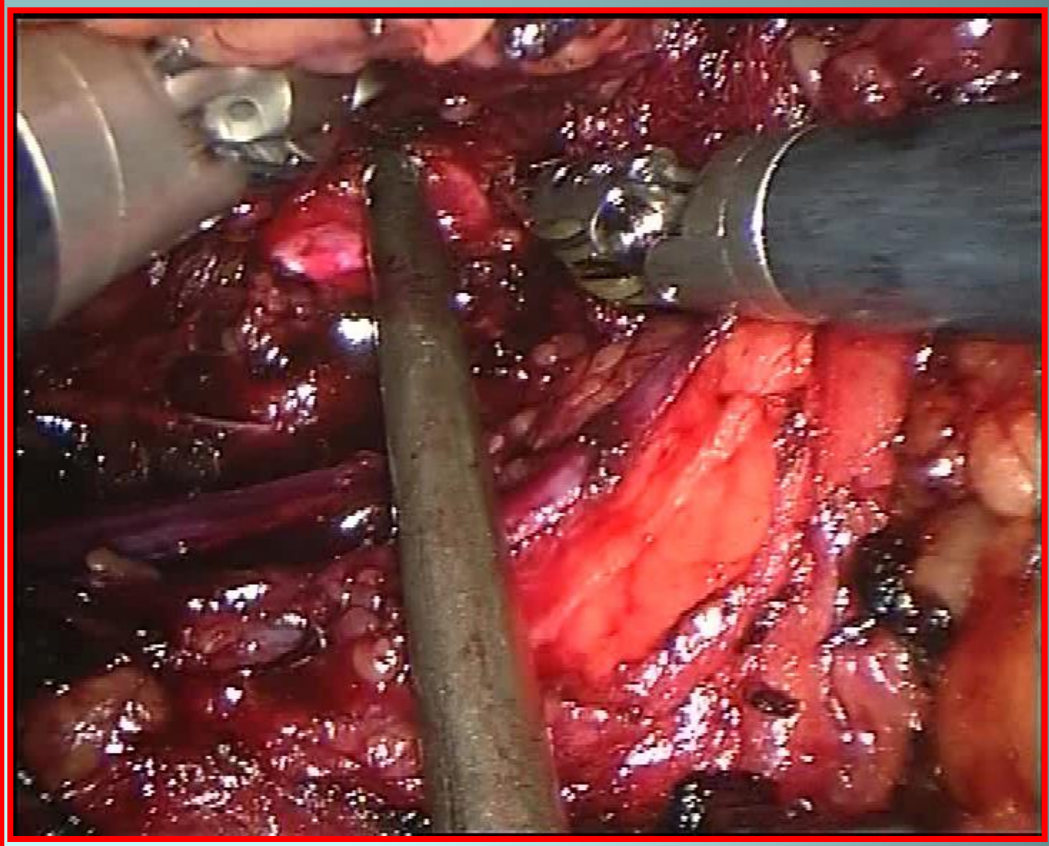
Robot-assisted splenic artery aneurysm treatment



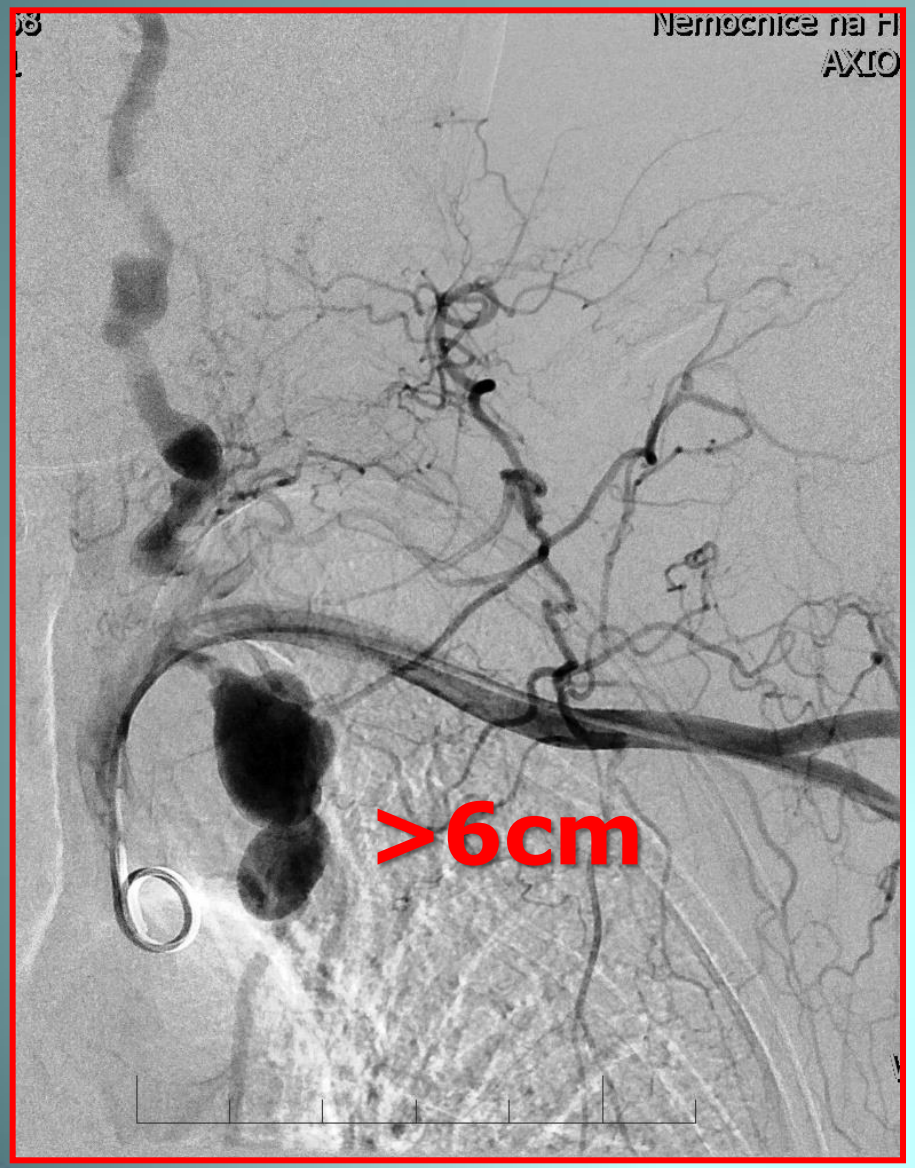


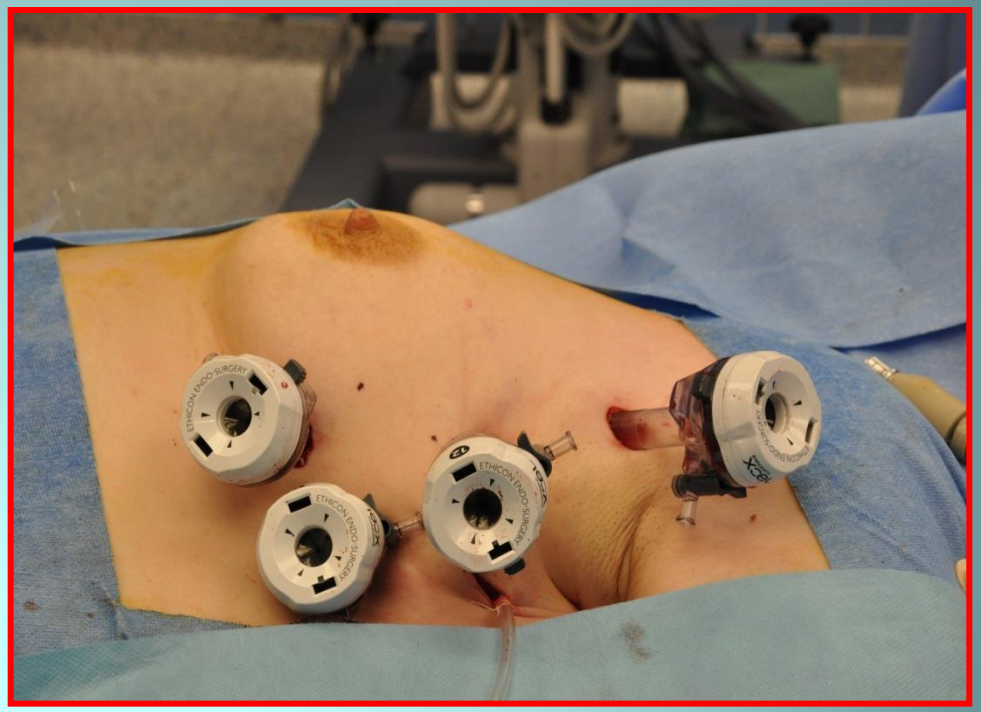
Robotic endoleak II. treatment





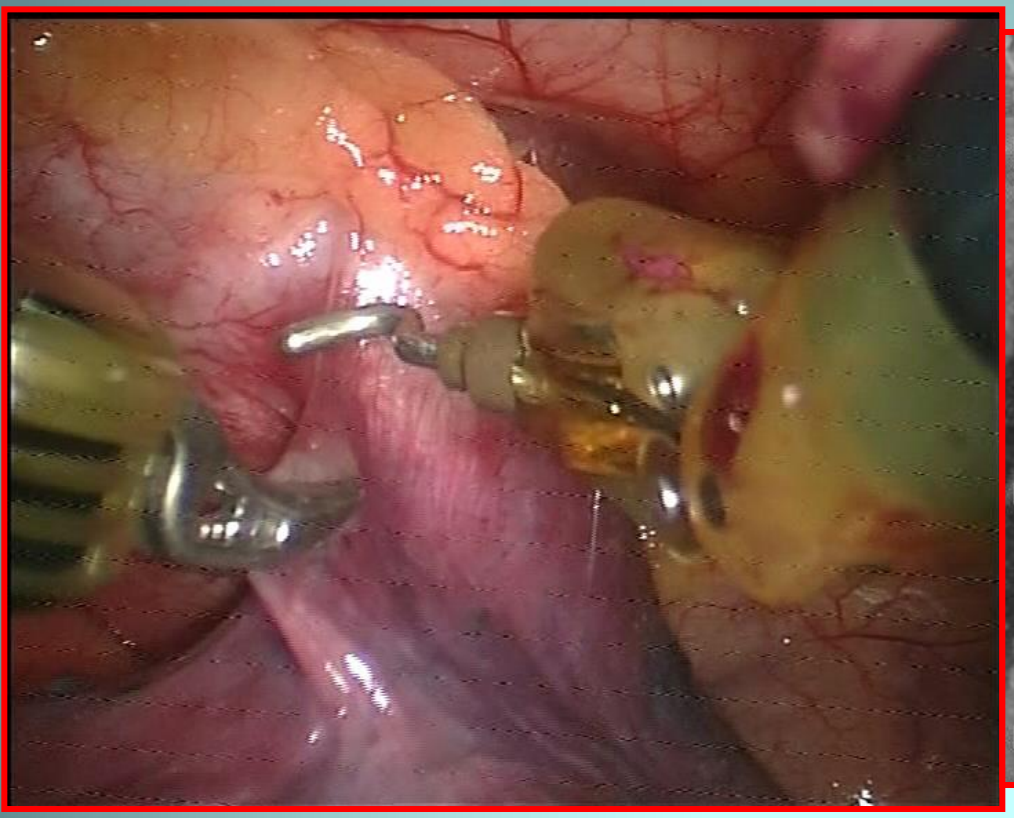
Mammary artery aneurysm treatment

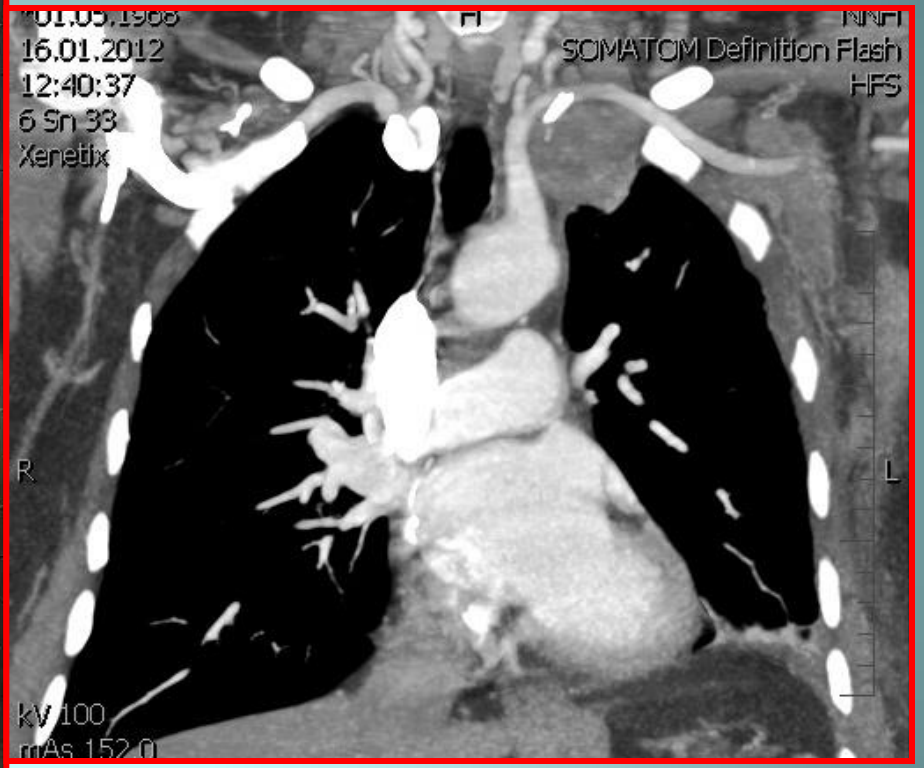




Woman, 1966, Marfan and Ehlers Danlos syndrome

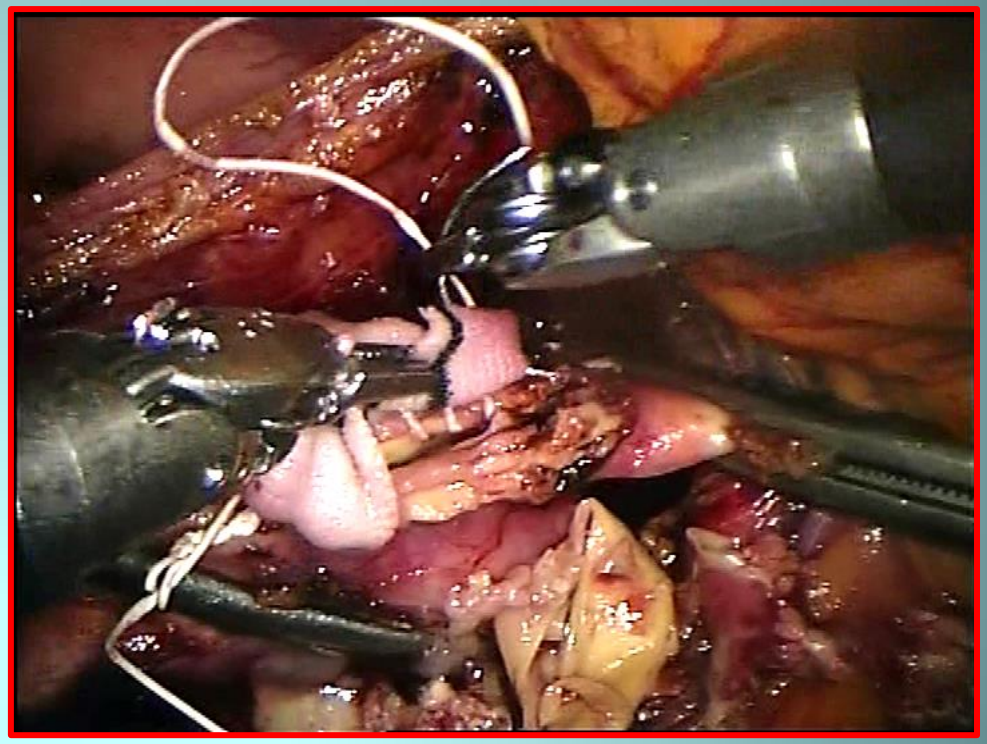
Mammary artery aneurysm treatment





Conclusion I.

* Robotic-assisted vascular surgery is very important step in development of laparoscopic surgery
* Laparoscopic experience is advantageous, not necessary
* Reducing the drawbacks (high cost, poor tactile feedback, etc.) should lead to an expansion of the use of robots in vascular surgery



The central anastomosis of the ABFB (End to side)

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Conclusion II.

* Robotic system to allow real start of minimally invasive surgery in the field of vascular surgery.

* Robotic system offers a true miniinvasive aortic surgery with all its advantages

Thank you very much for your attention!

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We can see a happy patient after robotic aortic surgery