Accepted Manuscript

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PII: S0890-5096(19)30240-7

DOI: https://doi.org/10.1016/j.avsg.2019.01.010

Reference: AVSG 4310

To appear in: *Annals of Vascular Surgery*

Received Date: 13 September 2018

Revised Date: 5 January 2019

Accepted Date: 13 January 2019

Please cite this article as: Martinelli O, Giglio A, Irace L, Di Girolamo A, Gossetti B, Gattuso R, SINGLE-CENTER EXPERIENCE IN THE TREATMENT OF VISCERAL ARTERY ANEURYSMS, *Annals of Vascular Surgery* (2019), doi: https://doi.org/10.1016/j.avsg.2019.01.010.

SINGLE-CENTER EXPERIENCE IN THE TREATMENT OF VISCERAL ARTERY ANEURYSMS

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This study was presented in Savannah during the meeting of the Eastern Society of Vascular Surgery 2017

Abstract

AIMS: Visceral artery aneurysms (VAAs), although rare, represent a life-threatening disease with high mortality rates. With the more frequent use of diagnostic tests, there has been an incidental detection of these lesions which are mostly asymptomatic. It follows that surgeons are increasingly called to decide the most appropriate management of VAAs between an open surgical or endovascular approach and among the different endovascular options currently available. The aim of this retrospective study was to evaluate the results of open surgery and interventional endovascular strategies of visceral artery aneurysms with respect to technical success, therapy-associated complications and post- interventional follow-up in the elective and emergency situation.

METHODS: From January 1992 to January 2017, 125 open surgical or endovascular interventions for VAA were performed at our institution. Once the VAA was diagnosed and the indication for treatment was assessed, the preoperative diagnostic workup consisted of contrast computed tomography (CT) or magnetic resonance imaging (MR) and, in some patients, digital subtraction

angiography. Follow-up included clinical and duplex ultrasound scan (DUS) and contrast enhanced ultrasound (CEUS) to assess the treated vessel patency and organ perfusion after 1, 6, and 12 months, and yearly thereafter. CT or MR controls were also performed at 1 year of follow-up and only when DUS was not diagnostic or showed a complication thereafter. After the first 5 years of follow-up, the status of the patient was obtained by a structured telephone survey.

RESULTS: The treatment option was endovascular in 56 out of 125 cases (44.8%). Technical success was 98.3%. In one case the procedure was interrupted for the extensive dissection of the afferent vessel. Twenty-six patients were treated by coils embolization while 29 with covered stenting. The endovascular approach was in emergency in two cases (3.6%). In the endovascular group, mortality was nil. Complications occurred in 5 cases (8.9%): 1 sub-acute intestinal ischemia caused by superior mesenteric artery dissection, 2 aneurysm reperfusion, 1 stent thrombosis and 1 massive splenic hematoma. In 69 (55.2%) surgical treatment was preferred, with 24 VAA resections and 45 arterial reconstructions. In 20 cases (29%), open surgery was performed in emergency conditions. In the surgical group, 8 emergency patients (40%) died intraoperatively. The mortality after elective surgical interventions was nil. Complications after surgery were 4 graft late thrombosis (5.8%): asymptomatic in three cases and requiring splenectomy in one.

CONCLUSIONS: There is no overall consensus regarding the indications for treatment of VAA. Currently in emergent setting, the endovascular approach should be considered as first choice, because of its reduced invasiveness, faster way to access and bleeding control; this accounts for the lower morality of the interventional therapy than open surgery

Endovascular approach is effective for elective repair of VAAs but, procedure-related complications may occur in a not negligible number of patients. Given comparable mortality rates and low procedure-related complication rate, surgical approach still has space in the elective management of VAAs, especially for aneurysms unsuitable or challenging for the endovascular

option in patient with low surgical risk. The size, location and morphology of VAAs, systemic or local comorbidities and specific anatomical situations such as previous abdominal surgery should dictate treatment choice.

Keywords: visceral artery aneurysm, open surgery, endovascular aneurysm repair, stenting, transcatheter embolization

Introduction

Visceral artery aneurysms (VAAs) represent a pathological condition with high mortality rates that ranging from 25%-100 because of their high risk of rupture and consequent fatal bleeding. [1] The VAAs may affect any of the branches of the abdominal aorta, although hepatic and splenic aneurysms account for 80% of those reported. Regardless of site and etiology, both true and pseudo-aneurysms VAAs are still rare occurrences with an incidence in autopsy and angiographic series of 0.01% to 2%.

Greater availability and increased use of advanced imaging technology, including computed tomography, magnetic resonance, ultrasonography, and arteriography, led to an increased incidental detection of asymptomatic visceral aneurysms. [2]

On account of this, the vascular surgeon must choose when to treat them more frequently, and with what approach: endovascular techniques (ET) or open surgery (OS). [3,4]

This retrospective study analyzes the results of open surgery and interventional therapy of aneurysms of the visceral artery in the elective and emergency situations. Special attention is paid to technical success, periprocedural morbidity, and late complications in order to define the current role of the surgical approach with respect to the endovascular treatment.

Methods

From January 1992 to January 2017, 125 patients (74 males and 51 females) with 131 true visceral arteries aneurysms were considered suitable for treatment. The mean age was 65 years. In 8 cases out of 125 an association with secondary small VAAs were found, but these were not considered for correction. In all cases, the preoperative diagnostic workup consisted of duplex color scan, angio-CT and angio-MRI. The site of aneurismal disease was renal artery (RA) in 45 patients (36%), splenic artery (SA) in 41 (32.8%), hepatic artery (HA) in 20 (16%), superior mesenteric artery (SMA) in 10 (8%), celiac trunk (CT) in 5 (4%), pancreatic-duodenal artery (PDA) in 3 (2.4%) and a distal branch of the left colic artery (LCA) in 1 (0,8%) (Table I).

According with our standard surveillance protocol, follow-up consisted of clinical and duplex ultrasound scan (DUS) and contrast enhanced ultrasound (CEUS) to assess the treated vessel patency and organ perfusion after 1, 6, and 12 months, and yearly thereafter. All patients were submitted to triphasic contrast-enhanced computed tomography (CT) or to Magnetic Resonance angiography (MR) at 12 months; after the first year, CT or MR controls were repeated when ultrasounds showed some modifications or in those cases in which DUS and or CEUS were unable to correctly follow the patients over time. The mean for follow- up using diagnostic imaging was 36 months (range: 18 – 60 months). After the first 5 years of follow-up, the status of the patient was obtained by a structured telephone survey.

Outcome Measures

The complete aneurysm exclusion on completion angiography was considered as technical success. while the clinical success implied the patency of the involved artery and target organ perfusion

Mortality and early and late complications were also assessed in both surgical and interventional groups.

Statistical analysis

Clinical data of the patients were extracted and entered into a spreadsheet. Overall survival and freedom from complications were calculated using Kaplan-Meier survival analysis. We applied the Log-rank test and considered the results to be significant at an alpha level of 0.05. SPSS Version 24 was used for data analysis.

Results

The treatment was carried out by an endovascular approach in 56/125 (44.8%) cases and consisted of embolization using either pushable coils or detachable coils at the discretion of the investigators, in 26: 5 RA, 18 SA, 1 SMA, 1 PDA, 1 branch LCA (Fig.1 A-B-C). The remaining 28 patients were submitted to covered stenting: 10 RA, 7 SA, 4 CT, 5 HA, 2 SMA. A Cardiatis a self-expandable stent multilayer was implanted in the common hepatic artery and in the SMA to preserve the pancreatic-duodenal artery and the ileo-colic artery, respectively (Fig. 4). In both patients, stent and collateral pathways remained patent during follow-up.

All procedures were performed under local anesthesia. In this endovascular group the intervention-related mortality was nil and two major complications occurred (3.6%). In one case, the endovascular treatment for covered stenting failed because of a superior mesenteric artery dissection with a complete acute thrombosis of the SMA with abdominal ischemia (1.8%). when attempting to cannulate the aneurysmal pancreaticoduodenal artery. This approach through the SMA was necessary because of the chronic occlusion of the CT and the tight angle of its origin

from the main artery. This patient was managed with watchful waiting and medical therapy and the 6-month-CTA control showed a recanalization of the thrombosed segment of SMA. In another case (1.8%), a large hematoma of the spleen occurred after SA embolization due to an inadequate distal control of the guidewire that caused an intra-parenchymal hemorrhage. This patient was treated conservatively and the 6-month DUS control showed the complete disappearance of the hematoma. Two patients (3.6%) were submitted to emergent endovascular coils embolization for rupture and hemorrhage due to a splenic aneurysm near-hilum and to a little aneurysm of a branch of the left colonic artery, respectively. In both cases, the postoperative course was uneventful.

Regarding the late complications, two patients submitted to transcatheter embolization (3.6%) had aneurysm reperfusion that was successfully retreated. One patient (1.8%) experienced a thrombosis of a covered stent implanted in the splenic artery after 1 year which required the splenectomy for massive spleen ischemia with concomitant abscess. No surgical conversion due to endovascular treatment failure or periprocedural complications was required.

Sixty-nine cases of this series, (55.2%) were submitted to open surgical treatment, mostly in the first phase of this experience. The surgical approach included ligation of the artery and re- section of the aneurysm in twenty-four aneurysms, vascular reconstruction and bypass in forty-five cases. In this last group, a renal auto-transplantation was carried out (Fig 3 A-B-C-D).

Out of 20 cases treated emergently (29%) for active bleeding VAAs, 8 patients (40%) died, all in shock before the procedure (Tab II). No deaths related to the elective surgical treatment of VAA occurred perioperatively and during follow-up.

The late complications following open surgery were: 4 graft occlusions (5.8%) which were asymptomatic in 3 cases and required a splenectomy in 1 patient.

When analyzing these data with the Kaplan Meier curves, 30-day-freedom from complication was 96.45% in the endovascular group (Figure 6) and 100%; while the 36-month freedom from

complication was 94.6% in the endovascular group and 98.6% in the open group, although these findings did not reach a statistical significance.

Discussion

There is no overall consensus regarding the indications for treatment of VAA. Nevertheless, it is worldwide accepted that indication for VAAs surgical or endovascular intervention are bases on several factors generally such VAA-related symptoms, a diameter exceeding 2 cm or exhibiting a rapid growth. The indications to treat can be expanded to include asymptomatic aneurysms regardless of size in affected women who wish to become pregnant, in childbearing age and in patients undergoing an orthotopic liver transplantation and VAAs with peripheral locations (branches of SMA, IMA, HA and RA).

The goal of treatment of VAAs is to exclude the aneurysmal sac from the systemic circulation while preserving perfusion of the target organ distal blood flow. For many years, open repair with aneurysm excision, exclusion and revascularization was the treatments of choice, but throughout the last decade endovascular repair including covered stenting and transcatheter embolization has become increasingly used. In our experience, the choice between surgery and endovascular intervention has been mainly based on anatomic suitability and patient comorbidities. It has also been influenced by the site of VAA and its anatomical and morphological characteristics and the need to occlude large efferent vessels emerging from the aneurysm.

In this study the outcomes of open surgery and interventional treatment are significant different in emergency compared to elective setting.

As similarly observed for ruptured abdominal aortic aneurysms[5], our experience, although not substantial, showed the highest perioperative morality of open surgery compared to the endovascular repair of bleeding VAAs. The reported mortality rate of surgery for treating actively

bleeding aneurysms has a mortality rate of 10 – 40 %, because it may be challenging due to aneurysm location and particular anatomical situations such as previous abdominal surgery, which can hinder a rapid control of the hemorrhage [6, 7].

Our data are, however, not suitable to achieve a comparative outcome analysis after surgical and interventional treatment due to the very small number of emergency cases which were treated by means of interventional techniques.

The great number patients who received an emergent surgical operation can be justify by the higher incidence of ruptured VAAs among the patients treated conservatively before the advent of the endovascular option as showed by Hogendoorn.[8]

There was no procedure-related mortality in both elective interventional and surgical management of VAAs This is very low in comparison to other series published (1.3%-7%); [9,10] only Pitton et al [11] presented a mortality comparable to ours. This is likely the result of the exclusion from the open surgery group of older patients with more comorbidities who were treated endovascularly or with conservative management, before we started practicing the endovascular approach. [12]

Furthermore, since the minimally invasive endovascular techniques may offer an advantage to conventional open repair in the presence of a hostile environment [13] in the last decade, the endovascular approach to VAAs has been our first option in the most challenging scene, such as abdominal sepsis or pancreatic inflammation. [14]

Consistently with other studies, endovascular intervention success rate of this series was high (98.3%); it was lower than open surgical intervention and this may be related to the increasing tendency to treat intravascularly the most technically challenging cases. [15]

Our data suggest, the interventional approach has a not negligible overall complication rate (8.9%). These data showed good comparability with other studies reporting complication rates up to 10.3%. [16,17]

The complication rate of the endovascular approach was even higher than after open surgery (6.6%). A more rigorous selection of cases to treat surgically can explain this difference. Another crucial point for failure after endovascular exclusion may be if the involved artery did have a suitable anatomy for the endovascular treatment, since the indication to this approach may sometimes be forced because it is less invasive than conventional surgery.

In addition, when we consider only the late complications, comparison of the 2 therapeutic options revealed similar incidence rates (5.4% after ET and 6.6% in after OS) while and reintervention rates (5.4% in ET vs 1.9% in OS) favored the surgical approach. This is analogous to what has been showed by Hemp and Sabri [18] who showed there is no significant difference regarding morbidity and mortality between interventional approach and open surgery while there was a significant reduction in the length of the hospital stay after interventional therapy.

In our single-center study, graft occlusion was always the late complication following open surgery and caused target organ ischemia requiring reintervention only in one out of four cases.

This lower reintervention rate following open surgery may be due the fact that the graft thrombosis developed progressively; this allowed time for collateral formation sufficient to prevent distal ischemia in the prevalence of the cases.

Aneurysm recanalization was the most frequent complication after interventional treatment; in this study it always occurred after coil embolization.

This raises the question about the choice of the most appropriate endovascular treatment (coil embolization vs covered stenting). In our experience this choice was influenced by the aneurysm morphology and the anatomy of the involved vessel. From our data, large saccular aneurysms may have poor long-term outcomes with coil embolization, as the coils may not be stable within the aneurysm and carry a higher risk of displacement and migration. In such cases, a covered stenting should be preferred when feasible. However, the development of microcatheter technology and the

use of microcoils have allowed for the selective catheterization of even small-caliber vessels and therefore a more targeted embolization. [19]

Detachable coils (eg, Interlock, Boston Scientific, Marlborough, MA) can be used especially in very tortuous arteries, when the catheter may not be stable in position while pushable Hydrogel coils (Terumo, Somerset, NJ) have the advantage of being more thrombogenic to achieve embolization with fewer coils in large VAAS.

In most cases covered stenting preserves the vessel patency with aneurysm exclusion and no risk of distal ischemia. However, it may be not feasible due to the tortuosity and not enough length of the involved artery as seen in our experience with renal stenting for stenosis. [20]

Additionally, the risk of stent thrombosis or restenosis can be higher in small caliber and more tortuous vessels. Anyway, currently, the improvements in the flexibility and adaptability of low-profile guide wires, newer low profile covered stents allow to treat endovascularly the most of cases in both elective and emergency situations.

The use of stent grafts to treat aneurysms of bifurcation points of the main or first order visceral rteries may result in occlusion of some of these branches with subsequent ischemia of the more or less extensive parenchyma. In this situation an interesting strategy is the exclusion of aneurysms using the Cardiatis multilayer stent as suggested by previous reports. [21,22]

In this series, the use of this device has shown encouraging results in term of long-lasting patency and collateral pathways preservation; anyway, two cases are not enough to draw definitive conclusion.

The potential for early and late complications such as aneurysm reperfusion and late thrombosis of the graft or of the stent requiring reintervention, necessitates a long-term follow-up using a multimodality approach after both surgical approach and endoluminal treatment. Following VAA

239 embolization, the diagnostic controls should combine contrast-enhanced US with MRI or CT
240 evaluation because imaging may be hampered by coil- induced artifacts. [23,24]
241 The study is mainly limited by its retrospective nature and and non-use of other endovascular options
242 (plugs, thrombin injection, and combined techniques). Although these two groups are comparable
243 for many variables (age, comorbidities, sex, etc.), the patients were treated in two different period:
244 until the year 2000, all patients of this series were submitted to open surgery and only after having
245 achieved an adequate experience in all endovascular techniques, this approach was carried out
246 routinely as shown in figure 5. However, it is worth noticing that this experience has collected the
247 largest series of true VAAs in the literature since most studies include only a small number of
248 patients only a few centers have reported experience with over 30 cases. [24,25]

249 **Conclusions**

250 Although this study cannot provide any definitive evidence about the indication and the best
251 treatment modality, the endovascular approach for VAAs is safe and technically feasible with low
252 morbidity and less invasiveness than open procedures. In emergency, it should be considered as
253 choice treatment because of its significantly lower perioperative mortality and faster way to access
254 open surgical treatment.
255 In elective setting, the choice of the best management is dictated almost on patient risks and
256 anatomy. Additionally, it depends on the morphology and site of the aneurysm, the length and
257 tortuosity of the parent artery and the need to prevent target organ ischemia.
258 The indications to the endovascular option and the choice of its techniques have to be evaluated
259 carefully to achieve technical success with long-lasting exclusion of the aneurysm and adequate
260 organ perfusion. Covered stenting seems to show a slightly better efficacy than transcatheter coiling
261 to prevent VAA reperfusion. The endovascular therapy and its tools continue to evolve, increasing
262 its applicability for the management of all aneurysms. However, the potential for early and late

failure of the endoluminal approach such as growth in sac size or leak, which would require reintervention is not neglectable. Thus, in subjects with a low surgical risk and aneurysm anatomy unsuitable for the endovascular treatment, open surgery has still a place as it guarantees a definitive repair with few late complications and reinterventions during follow-up.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

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DISTRICT INVOLVED	N° OF PATIENTS (%)
Renal Artery	**45 patients (36%)**
Splenic Artery	**41 patients (32,8%)**
Hepatic artery	**20 patients (16%)**
Superior Mesenteric Artery	**10 patients (8%)**
Celiac Trunk	**5 patients (4%)**
Pancreatic-duodenal artery	**3 patients (2,4%)**
Distal branch of the left colic artery	**1 patient (0,8%)**

Table I. Different localization of VAA

Endovascular treatment 56/125	Embolization	26	**44%**
	Covered stent	29	
	Failed procedure	1	**0,8%**
Surgical treatment 69/125	Resection	24	**55,2%**
	Vascular reconstruction	45	

Table II. Different approaches of treatment

	Total Cohort (n=125)	Endovascular Treatment (n=56)	Open Surgery (n=69)
Aneurysm type	131 VAA	60 VAA	71 VAA
Affected arteries,: sites	45 RA, 41 SA, 20 HA, 10 SMA, 5 CT, 3 PDA, 1 LCA	15 RA, 25 SA, 5 HA, 3 SMA, 4 CT, 1 PDA, 1 LCA	30 RA, 16 SA, 15 HA, 7 SMA, 1 CT, 2 PDA
Procedures	103 elective, 22 emergency	54 elective, 2 emergency	49 elective, 20 emergency
Technical success	92,5%	98.3%	94.2%
Major complications	9	5	4
Thirty-day mortality	8	0	8[a]
Vessel preservation	101	56	45
Target organ ischemia	2	2[b]	0

Abbreviations: VAA, visceral artery aneurysm; RA, renal artery; SA, splenic artery; HA, hepatic artery; SMA, superior mesenteric artery; CT, celiac trunk; PDA, pancreatic duodenal artery; LCA, left colic artery.

[a] 8 Emergency

[b] One early, one late complication

Table III. Patients undergoing treatment for Visceral Artery Aneurysms

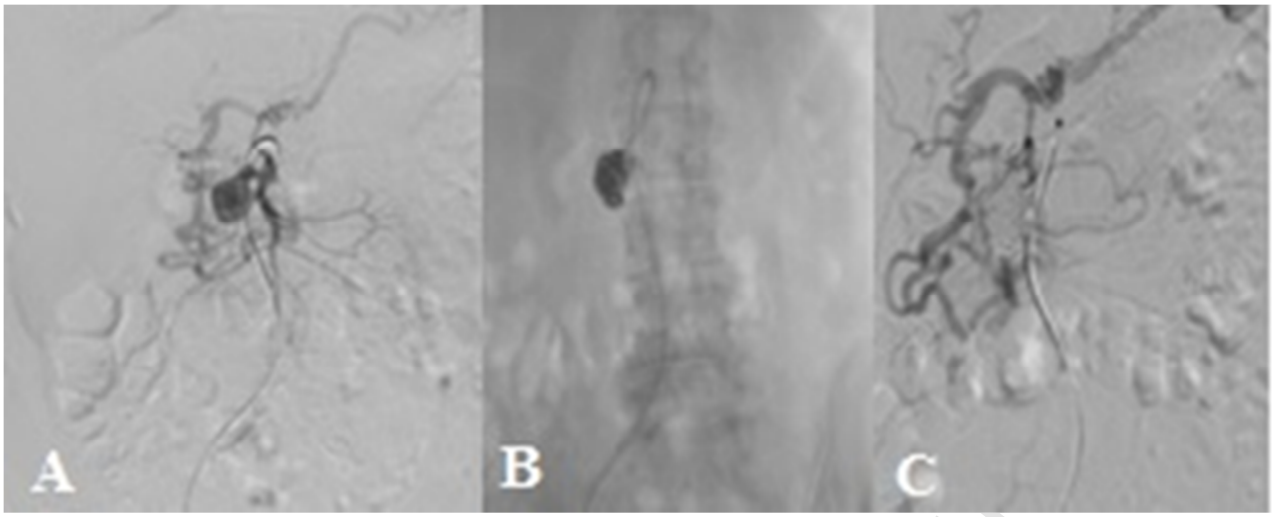

Fig. 1

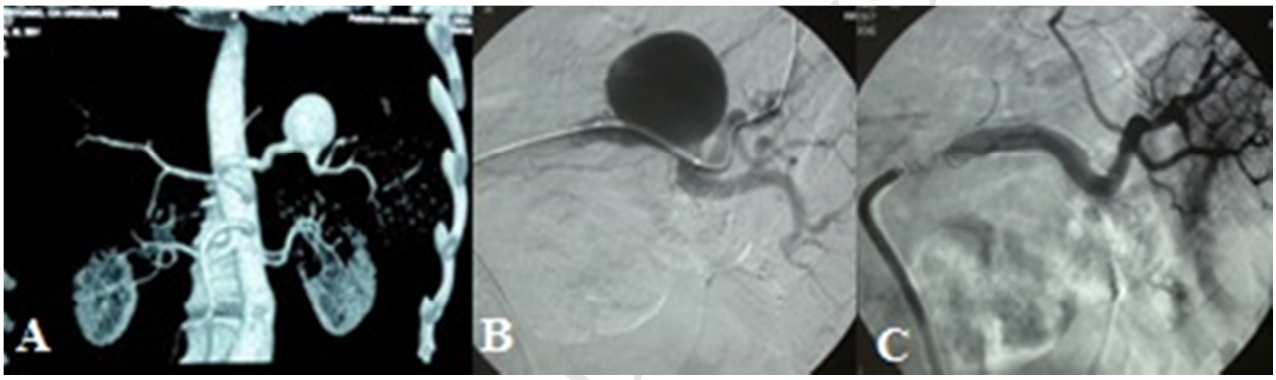

Fig. 2

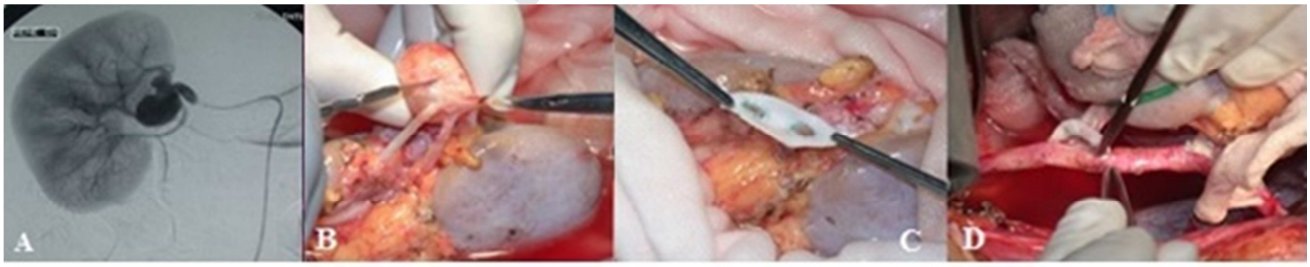

Fig. 3

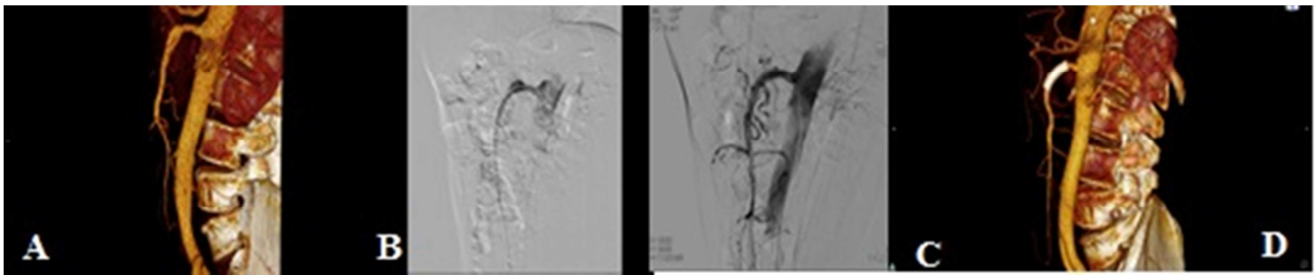

Fig. 4

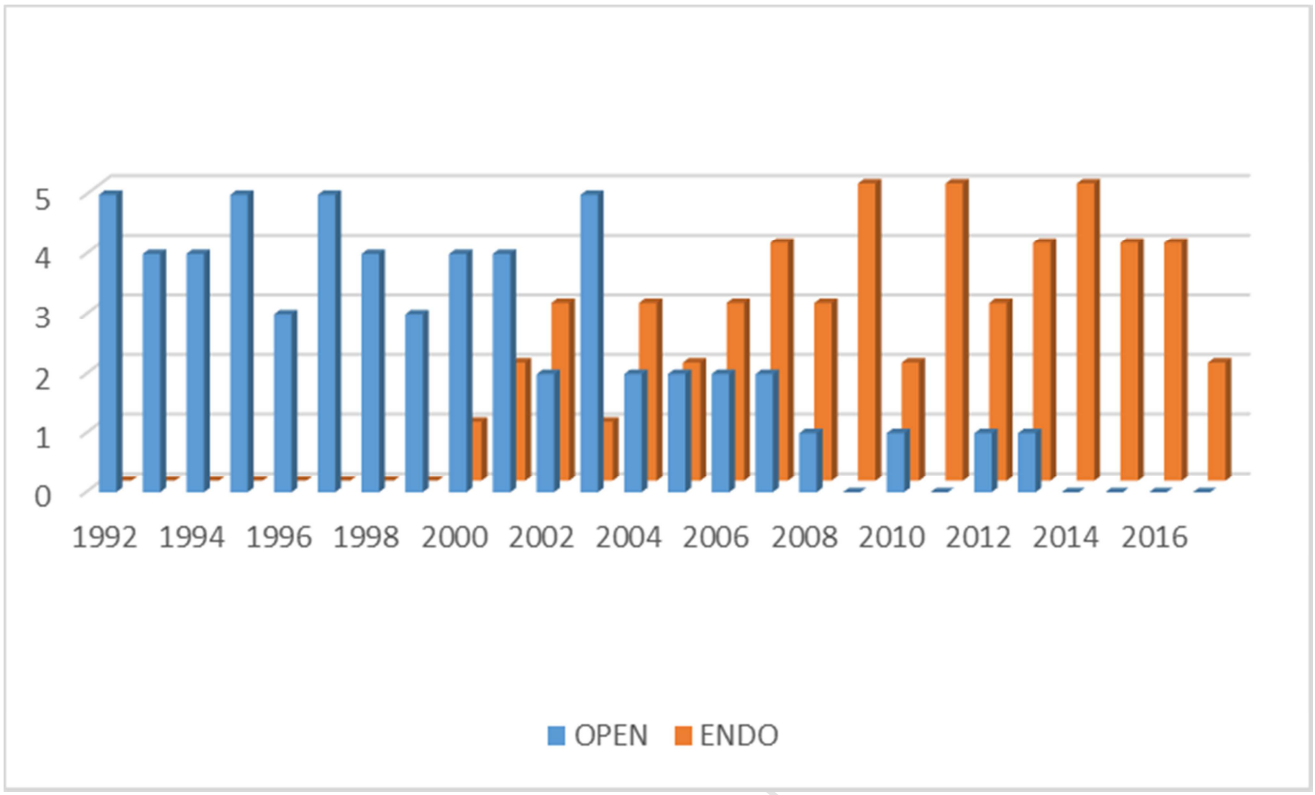

Fig. 5

Figure 1. A) Intraoperative angiogram of a pancreatic-duodenal artery aneurysm; B) Coils embolization of the PDA aneurysm; C) Final angiogram showing the complete embolization of the aneurysm

Figure 2. A) 3D reconstruction showing a splenic artery aneurysm; B) Intraoperative angiogram of the same splenic artery aneurysm; C) Intraoperative angiogram showing a covered stent deployment to exclude the aneurysm.

Figure 3. A) Intraoperative angiogram of an pararenal artery aneurysm; B) Intraoperative picture of the renal artery aneurism resection; C) Replanting of the two renal arteries on Teflon patch; D) Kidney replanting in iliac fossa with anastomosis on external iliac artery and vein

Figure 4. A) Preop. angioCT that shows a dissection of the SMA with aneurismal dilatation. B-C) Angiographic images of Cardiatis stent deployement D) Control angioCT at 31 months that shows clearly a patency of the implanted Cardiatis stent.

Figure 5. Graphic shows different approaches during the period examined.