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Treatment options for visceral artery aneurysms: ten year experience

D. MAZZACCARO [1], M. CARMO [1], G. NANO [2, 3], I. BARBETTA [1], A. M. SETTEMBRINI [1], M. T. OCCHIUTO [2], S. STEGHER [2], R. DALLATANA [1], G. MALACRIDA [2], P. G.SETTEMBRINI [1, 3]

[1]Division of Vascular Surgery
Ospedale San Carlo Borromeo, Milan, Italy
[2]First Division of Vascular Surgery
IRCCS Policlinico San Donato
San Donato Milanese, MIlan, Italy
[3]University of Milan, Milan, Italy

Aim. **Open surgical repair (OSR) and endovascular techniques (ET) are both described in the literature for treating visceral artery aneurysms (VAAs). Aim of this study is to report a two-center experience of patients treated for a VAA using either OSR or ET, analyzing perioperative outcomes.**

Methods. **Clinical data of 32 VAAs in 32 patients treated between January 2001 and May 2011 were retrospectively reviewed and outcomes analyzed.**

Results. **Eighteen patients were men (56.3%). Median age was 64 years (range 26-79). Sixteen aneurysms were symptomatic: half of them were ruptured causing hemoperitoneum or gastrointestinal bleeding. ET were employed in 19 cases (59%) using covered stents (7 patients), coil embolization (5), plug placement (1), thrombin injection (2) and multiple associated techniques (4). OSR consisted in aneurysmectomy with end to end anastomoses (5 patients) or interposition graft (1), aneurysm ligation (4), splenectomy (2). One patient died during open surgery for hemoperitoneum due to VAA rupture (3%). OSR and ET had similar perioperative complication rates (5.2% *vs.* 15.3%, P=0.76). OSR had a longer in-hospital stay than ET (8 *vs.* 4 days, P=0.04). The presence of pancreatitis and alcohol abuse were more frequent in patients who presented with VAAs rupture. Clinical presentation with hemoperitoneum or aneurysm rupture were associated with higher mortality, regardless of the type of treatment.**

Conclusion. **Both OSR and ET offered a safe way to treat VAAs in our experience.**

KEY WORDS: Endovascular procedure - Surgical procedures, operative - Aneurysm.

Visceral artery aneurysms (VAAs) are a relatively rare disease, accounting for 5-8% of all aneurysms with a reported annual incidence between 0.1 and 2% in different published series. However, they may occur as surgical emergencies in 25% of cases, being fatal in 8.5% of cases.[1] These aneurysms are often incidental findings during abdominal imaging and they are mainly asymptomatic. Surgical treatment is recommended for those at high risk of rupture.

Open surgical repair (OSR) and endovascular techniques (ET) are both described in the literature for treating VAAs. Surgery remains the mainstay in case of rupture,[2] but when the aneurysms is located within the parenchima of solid organs (such as liver) or in an anatomical site unfavourable for surgical access (*i.e.* behind the head of the pancreas or surrounded by numerous collateral branches), a less invasive approach is preferred.[3, 4] It is mostly employed for elective treatment, but it can be helpful also in an emergency setting, providing a fast bleeding control in selected cases.[5]

Aim of this study is to report the results of patients treated for a VAA using either OSR or ET in two centres (Division of Vascular Surgery, San Carlo Borromeo Hospital, Milan, and I[st] Unit of Vascular Surgery, IRCCS Policlinico San Donato, San Donato Milanese), and to analyze perioperative and long term outcomes.

Corresponding author: M. Carmo, MD, Division of Cardiovascular Surgery, Carlo Borromeo Hospital, Via Pio II 3, 20153 Milan, Italy. E-mail: michele.carmo@unimi.it

TABLE I.—*Treatment of VAA using either OSR or ET.*

Sex	Age	Clinical presentation	Emergent	Localization	Intervention
F	75	Hemoperitoneum (rupture)	Y	Gastroepiploic	Aneurysmectomy with end to end anastomosis
F	78	Asymptomatic	N	Splenic	Plug & coils
M	74	Asymptomatic	N	Splenic	Coil embolization
F	71	Asymptomatic	N	Splenic	Covered stent (after a failed attempt of embolization with coils)
F	44	Asymptomatic	N	Splenic	Plug & coils
M	59	Asymptomatic	N	Splenic	Aneurysm ligation
M	74	Asymptomatic	N	Splenic	Splenectomy
F	55	Hemoperitoneum (rupture)	Y	Splenic	Covered stent
F	75	Asymptomatic	N	Splenic	Plug placement
M	28	Asymptomatic	N	Hepatic	Thrombin injection
M	74	Gastrointestinal bleeding (rupture)	Y	Gastroduodenal	Coils, glue & thrombin
F	57	Hemoperitoneum (rupture)	Y	Splenic	Splenectomy
F	73	Abdominal pain	N	SMA	Thrombin injection
F	34	Asymptomatic	N	Splenic	Aneurysmectomy with end to end anastomosis
F	59	Hemoperitoneum (Rupture)	Y	Pancreaticoduodenal	Explorative laparotomy
M	64	Asymptomatic	N	Hepatic	Aneurysmectomy with interposition graft
F	26	Obstructive jaundice	N	Hepatic	Covered stent
M	46	Abdominal pain	N	Hepatic	Covered stent
M	68	Asymptomatic	N	Hepatic	Covered stent
M	74	Hemoperitoneum (rupture)	Y	Pancreaticoduodenal	Aneurysm ligation
F	67	Abdominal pain	N	Splenic	Aneurysm ligation
M	72	Asymptomatic	N	Gastroduodenal	Aneurysm ligation
M	78	Asymptomatic	N	SMA	Coil embolization
M	28	Acute pancreatitis	N	Gastroduodenal	Coils & Thrombin
M	58	Abdominal pain	N	Splenic	Coil embolization
M	64	Abdominal pain	N	Celiac trunk	Coil embolization
M	56	Gastrointestinal bleeding (Rupture)	Y	Hepatic	Aneurysmectomy with end to end anastomosis
F	49	Asymptomatic	N	Splenic	Covered stent
F	52	Asymptomatic	N	Splenic	Aneurysmectomy with end to end anastomosis
M	71	Gastrointestinal bleeding (rupture)	Y	Gastroepiploic	Aneurysmectomy with end to end anastomosis
M	79	Abdominal pain	N	Hepatic	Covered stent
M	47	Asymptomatic	N	Splenic	Coil embolization

Materials and methods

Clinical data of all patients treated between January 2001 and May 2011 for VAAs were retrospectively reviewed. Patients with symptomatic or asymptomatic aneurysms of the celiac axis, superior mesenteric artery (SMA), inferior mesenteric artery, and their branches, were included in the study, while renal artery aneurysms were excluded.

Data regarding preoperative status, operative details and postoperative course were extracted from charts.

Preoperative demographic data included age, sex, cardiovascular risk factors, history of pancreatitis, alcohol consumption, liver disease and neoplasm; women were also asked for pregnancy status and number of previous pregnancies. The study was approved by the committee on research ethics at the institution in which the research was conducted and

any informed consent from human subjects was obtained as required.

Aneurysms' presence was diagnosed using color-doppler ultrasound (DUS) or computed tomography angiography (CTA). Data about diameter, morphology, location and rupture of VAA were recorded.

The choice between OSR and ET depended upon patients' clinical presentation, as well as aneurysm location (Table I).

Data regarding postoperative course included in-hospital stay and patients' clinical status after discharge (death, occurrence of any type of complications, reintervention).

All patients treated with ET underwent a DUS control before discharge. There was no standard protocol for follow-up: patients were visited at 1, 6 and 12 months and therefore annually. DUS was largely employed during follow-up visits while CTA was performed any time DUS results were considered not diagnostic, *i.e.* because of the deep location or the presence of artifacts. Images were evaluated to assess regular patency of graft and, for ET, complete exclusion of the aneurysm. All patients were also interviewed for long term follow-up by telephone calls.

Statistical analysis

All data were entered in a specific database with the software JMP® 5.1 (SAS Institute). Outcomes between groups were analyzed using log-rank test, chi2 and Wilcoxon, as appropriate. P values were considered statistically significant if <0.05.

Results

Thirty-two patients were treated in the two centers: eighteen were men (56.3%). Median age was 64 years (range 26-79). Patients' demographic are listed in Figure 1. Median sac diameter was 2.7 cm (range 1.6-9 cm). There was a case of giant aneurysm of the second branch of the superior mesenteric artery (9 cm), which presented with abdominal pain and a pulsating mass in lower abdomen.

Sixteen patients were asymptomatic, while another 16 were symptomatic: half of them had a rupture causing hemoperitoneum or gastrointestinal bleeding. Five patients were symptomatic for abdominal pain, 2 had acute pancreatitis and 1 had obstructive jaundice.

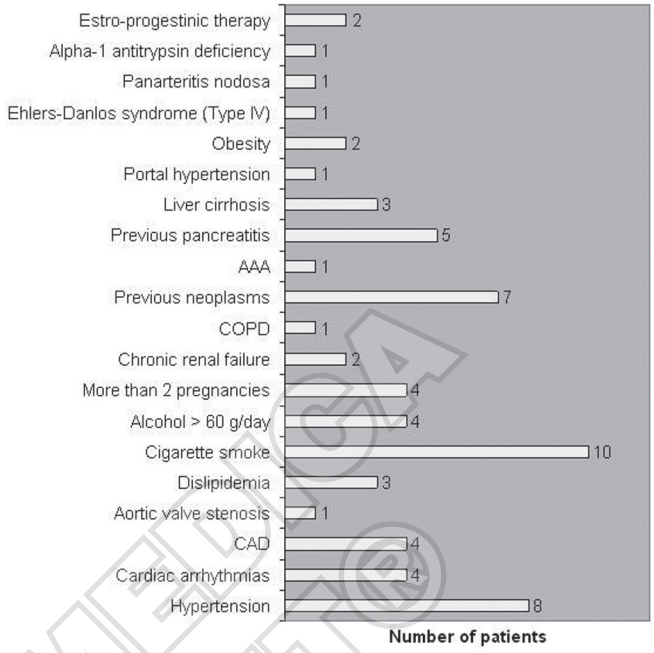


Figure 1.—Patients' demographic.

Asymptomatic patients were treated when VAA diameter exceeded 2 cm.

The vessel involved was the splenic artery in fifteen cases (46.9%), in 7 the hepatic (21.8%), in 5 gastroduodenal or pancreaticoduodenal artery (15.6%) in 2 the gastroepiploic and the SMA (both 6.3%), and in 1 the celiac trunk (3.1%). Two patients with hepatic aneurysm were affected by Ehlers-Danlos Syndrome (Type IV) and polyarteritis nodosa, respectively; an alpha-1 antitrypsin deficiency was found in a patient with a gastroduodenal aneurysm. None of the female patients was pregnant at the time of intervention.

ET was performed in 19 cases (59%): covered stents were used in 7 patients, coil embolization in 5, thrombin injection in two cases and a vascular plug in one. Multiple techniques were associated in 4 patients: plugs were positioned in the proximal and distal necks after aneurysms embolization with coils in 2 cases; metal coils and thrombin were used together in another one. In the last patient the aneurysm was embolized using coil, glue and thrombin in sequence.

The giant aneurysm of the SMA was treated with complete exclusion using transcatheter thrombin injection, because of very difficult surgical approach-

TABLE II.—*Comparison between OSR and ET. Significant P value are in bold.*

	OSR	ET	P
In-hospital stay (median, days)	8	4	0.04
ICU (median, days)	2.5	2	0.17
Lenght of intervention (median, minutes)	135	65	<0.0001
30-days mortality	8%	0%	0.21
30-days complication rate	15.3%	5.2%	0.76

*ICU: Intensive Care Unit

ability of the lesion and the high risk of rupture during surgical maneuvers. All ET but one were performed using a percutaneous femoral access; in the patient affected by Ehlers-Danlos Syndrome exposure of his right femoral artery allowed to obtain a sample of tissue for histology.

Eighteen out of 19 VAAs treated with ET were successfully excluded at first attempt (94.8%). In one case an asymptomatic splenic artery aneurysm was electively treated using transcatheter coil embolization. Two days later, the patient being asymptomatic, DUS control before discharge documented reperfusion of the aneurysm possibly due to the migration of the metal coils. A CTA confirmed the reperfusion of the aneurysm, in the absence of any signs of splenic infarction. Therefore, a second endovascular procedure was performed and a covered stent was placed to obtain complete exclusion. His postopervative course was complicated by a splenic infarction.

OSR consisted in aneurysmectomy with end to end anastomosis (5 patients), simple aneurysm ligation (4), splenectomy (2), and in one case an interposition graft. One patient died during laparotomy for hemoperitoneum due to VAA rupture (3%). One of the two splenectomies was performed electively one month after anti-pneumococcal, haemophilus and meningococcal vaccination.

The median duration of intervention was 65 minutes for ET (IQ range 60-75 minutes) and 135 minutes for OSR (IQ range 125-191 minutes), P<0.001.

After ET, 2 patients experienced respectively a temporary increase of pancreatic amylase and serum creatinine (the third complication was the aforementioned splenic infarction); there were no access-related complications. Among OSR one patient experienced a transient raise of pancreatic amylase; a second patient developed a pancreatic abscess following a splenic aneurysm ligation; unfortunately the abscess (although drained) turned into sepsis, leading to death on POD 90; a third patient had a pancreatic fistula after a right gastroepiploic aneurysm resection.

OSR had a longer median in-hospital stay than ET (8 *vs.* 4 days, P=0.04) (Table II).

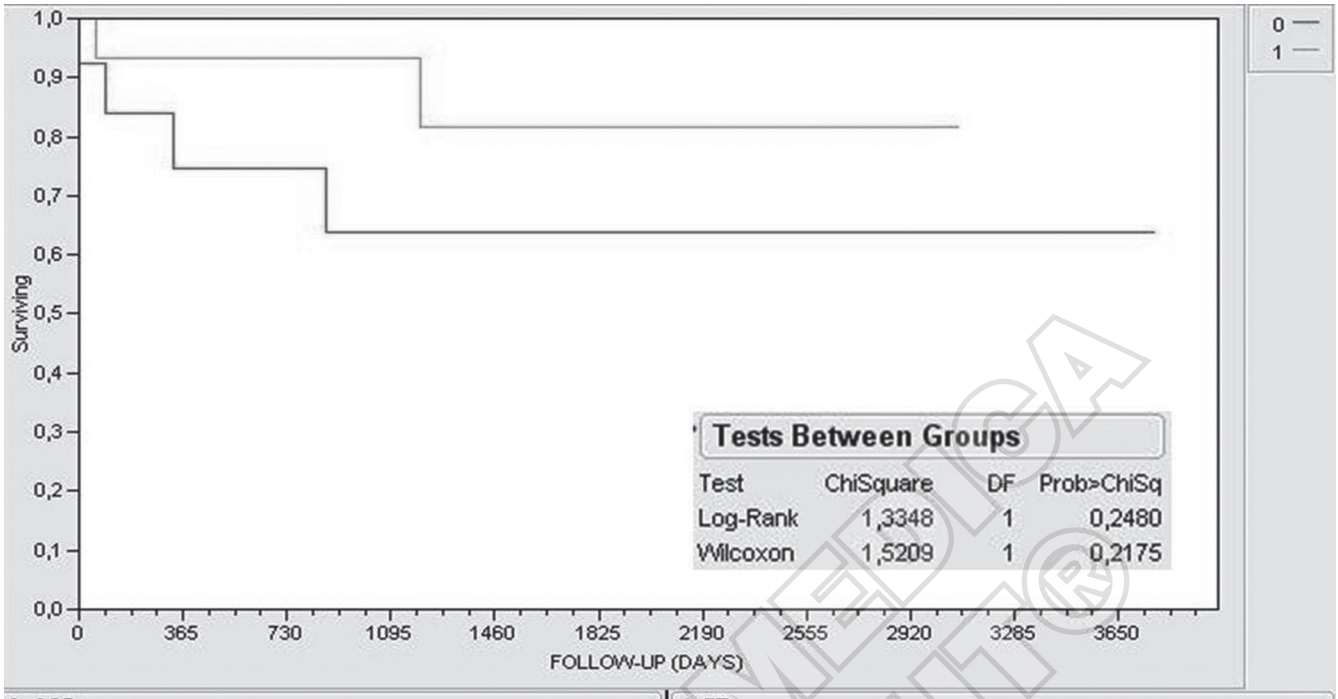
Four patients treated with OSR were admitted to the intensive care unit (ICU) in the postoperative period (31%): the median length of stay was 2.5 days (range 0-6 days). Among patients treated with ET, only two patients were admitted to the ICU (11%), for a mean of 2 days.

OSR and ET had similar perioperative complication rates (15.3% vs 5.2%, p=0.76).

Long-term outcomes were available for 28 patients (87.5%), with a median follow-up of 29 months (range 0-126 months). Five patients died during follow-up (Table III). Long-term survival rate for ET was 93.3±6.4% at 1 and 3 years and 81.7±12.3% at

TABLE III.—*Data of long-term mortality.*

Sex, Age	Comorbidities	Symptoms	Localization	Intervention	Time to event (days)	Cause
M, 28	Chronic renal failure, Neoplasm	None	Hepatic	Thrombin injection	60	Chronic renal failure
F, 57	Arrhytmia, Tobacco smoke, Alcohol, COPD, Neoplasm, Pancreatitis, Liver cirrhosis, Obesity	Hemoperitoneum	Splenic	Splenectomy	90	Sepsis
F, 59	Pancreatitis	Hemoperitoneum	Pancreaticoduodenal	Explorative laparotomy	During operation	
M, 74	CAD, Pancreatitis	Hemoperitoneum	Pancreaticoduodenal	Aneurysm ligation	330	MOF
M, 78	Neoplasm	None	SMA	Coil embolization	1200	Acute liver failure
M, 71	Alcohol, Neoplasm, Pancreatitis	Gastrointestinal bleeding	Gastroepiploic	Aneurysmectomy with end to end anastomoses	870	Pulmonary metastasis



0=OSR

FOLLOW-UP (days)	Survival	Failure	SurvStdErr	N Failed	N Censored	At Risk
0,00	1,0000	0,0000	0,0000	0	0	13
0,00	0,9231	0,0769	0,0739	1	0	13
30,00	0,9231	0,0769	0,0739	0	1	12
90,00	0,8392	0,1608	0,1045	1	0	11
270,00	0,8392	0,1608	0,1045	0	1	10
330,00	0,7459	0,2541	0,1279	1	0	9
570,00	0,7459	0,2541	0,1279	0	1	8
870,00	0,6394	0,3606	0,1475	1	0	7
990,00	0,6394	0,3606	0,1475	0	1	6
1410,00	0,6394	0,3606	0,1475	0	1	5
2430,00	0,6394	0,3606	0,1475	0	1	4
2610,00	0,6394	0,3606	0,1475	0	1	3
3150,00	0,6394	0,3606	0,1475	0	1	2
3780,00	0,6394	0,3606	0,1475	0	1	1

1=ET

FOLLOW-UP (Days)	Survival	Failure	SurvStdErr	N Failed	N Censored	At Risk
0,00	1,0000	0,0000	0,0000	0	0	15
60,00	0,9333	0,0667	0,0644	1	0	15
180,00	0,9333	0,0667	0,0644	0	1	14
210,00	0,9333	0,0667	0,0644	0	2	13
390,00	0,9333	0,0667	0,0644	0	2	11
870,00	0,9333	0,0667	0,0644	0	1	9
1200,00	0,8167	0,1833	0,1228	1	0	8
1230,00	0,8167	0,1833	0,1228	0	1	7
1440,00	0,8167	0,1833	0,1228	0	1	6
1620,00	0,8167	0,1833	0,1228	0	1	5
1860,00	0,8167	0,1833	0,1228	0	1	4
2280,00	0,8167	0,1833	0,1228	0	1	3
2460,00	0,8167	0,1833	0,1228	0	1	2
3090,00	0,8167	0,1833	0,1228	0	1	1

Figure 2.—Long-term survival rate after ET and OSR.

5 years. Survival rate for OSR was 74.6%±12.8% at 1 year and 63.9±14.7% at 3 and 5 years (P=0.24) (Figure 2). No aneurysm-related complications were detected at long term.

We investigated for factors potentially associated with acute presentation due to VAA rupture (Table IV): the presence of pancreatitis and a daily alcohol consumption exceeding 60 g were more frequent in patients who presented with VAAs rupture.

We also performed a univariate analysis to test preoperative risk factors potentially associated with mortality (Figure 3) or 30-day complications (Table V). Age-adjusted analysis showed that a history of pancreatitis and liver cirrhosis were significantly associated with mortality, while a weak association was found between the presence of alcohol consumption or previous cancer and mortality. Clinical presentation with hemoperitoneum or aneurysm rupture were associated with higher risk of mortality, regardless of the type of treatment. On the other side, no factors were found to be significantly associated to the occurrence of 30-day complications.

TABLE IV.—*Factors associated with clinical presentation of ruptured VAA after treatment (Odds Ratio expressed with 95%Confidence Interval and P value).*

	Rupture		
	ODDS Ratio	95% CI	P Value
Male sex	0.71	0.13-3.68	0.68
Hypertension	1	0.12-5.87	1
CAD	3.66	0.37-36.37	0.23
Dislipidemia	1.57	0.06-19.01	0.72
Cigarette smoke	0.23	0.01-1.66	0.21
Alcohol >60 g/die	13.8	1.44-314.22	0.03
More than 2 previous pregnancies	1	0.04-9.38	1
Neoplasms	1.26	0.15-7.79	0.80
Liver Cirrhosis	7.66	0.63-182.47	0.01
Pancreatitis	22.99	2.61-520.67	0.01
Diameter of VAA	0.73	0.01-287.23	0.89

*CAD: coronary artery disease

TABLE V.—*Factors associated with clinical presentation of complications after treatment (Odds Ratio expressed with 95%Confidence Interval and P value).*

	30-day complication		
	ODDS Ratio	95% CI	P Value
Male sex	1	0.24-4.10	1
Hypertension	0.50	0.09-2.55	0.41
CAD	3.46	0.39-74.81	0.30
Dislipidemia	0.46	0.02-5.40	0.55
Cigarette smoke	0.55	0.11-2.50	0.44
Alcohol > 60 g/die	3.46	0.39-74.81	0.30
2 or more pregnancies	1	0.10-9.30	1
Neoplasms	3.18	0.56-25.32	0.25
Liver Cirrhosis	2.14	0.18-49.14	0.31
Pancreatitis	4.99	0.63-104.88	0.17
Diameter of VAA	0.002	0.00000-0.91	0.11

*CAD: coronary artery disease

Discussion

Visceral artery aneurysms (VAAs) are a rare disease: only small case series are reported in the literature, with sporadic series exceeding 70 cases described for each-center over a long period.[2] Management of VAA is however challenging, given the high mortality related to their rupture, independently from their etiology.[6]

The choice of surgical strategy is usually tailored on the clinical condition of the patient and the location of the aneurysm.

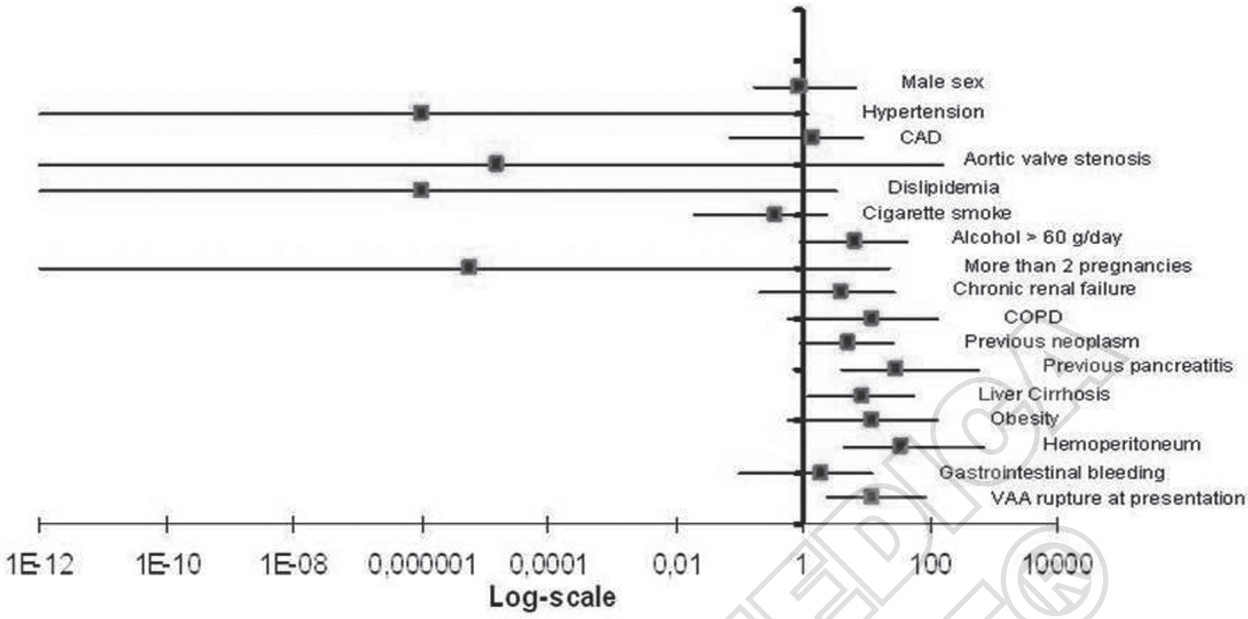
In 41% of the patients we opted for OSR. The technique used in most cases was resection or ligation of the aneurysm for both centers. Reconstruction of the vessels was performed when collateral circulation was inadequate, using direct end-to-end anastomosis whenever possible. In case of aneurysms of the splenic artery, when the lesion was too distal or when ischemic complication occurred, a splenectomy was performed. Our policy is however to preserve the spleen whenever possible to prevent infectious complication.

ET was performed using different techniques: a covered stent was used in presence of favorable anatomic conditions (good proximal and distal neck, absence of tortuosity of vessels), allowing the exclusion of the aneurysm without compromising blood flow downstream. Thrombin injection in our experience showed to be a safe method; it was used to treat a giant aneurysm of the second branch of the superior mesenteric artery in a patient who could not be operated on for high surgical risk.[7] Endovascular techniques can also be used jointly, in order to obtain a better technical result. Recently, aneurysm exclusion with multilayer stents has been reported in literature, with favourable outcomes.[8] This new endovascular graft has raised a lot of interest, because it allows for the exclusion of the aneurysm without compromising flow to patent collateral vessels arising from the sac or neck. However data about its efficacy and safety in this particular setting are lacking and none of our patients was treated with this new technique.

Literature has paucity of data from a direct comparison between OSR and ET (Table VI).

It is well known that ET is less invasive than OSR, in terms of duration of the operation, need for intensive care and recover after intervention. Our results confirm this, as in-hospital stay was shorter after ET than after OSR (8 *vs.* 4 days, P=0.04); 30-day complications were similarly reduced for ET.

In our series ET allowed for the treatment of VAAs in a cohort of patients in which the presence of significant comorbidities or technical difficulty elevated the risk of major vascular operations. A concern exists however about safety of ET, as this approach not always allows to save a direct flow through the



HR = Hazard Ratio

	HR	95% Lower CI	95% Upper CI	P value
Male Sex	0,93	0,17	6,76	0,93
Hypertension	0,000001	1E-12	1,18	0,07
CAD	1,44	0,07	9,06	0,74
Aortic valve stenosis	0,000016	1E-12	157,3	0,78
Dislipidemia	0,000001	1E-12	3,36	0,25
Cigarette smoke	0,38	0,02	2,42	0,34
Alcohol > 60 g/day	*6,94*	*0,89*	*43,19*	*0,06*
More than 2 pregnancies	0,000006	1E-12	22,68	0,62
Chronic renal failure	3,93	0,2	26,96	0,29
COPD	12,64	0,58	132	0,09
Previous neoplasms	*5,14*	*0,91*	*28,92*	*0,06*
Previous pancreatitis	**30,03**	**4,25**	**600,01**	**0,0006**
Liver cirrhosis	**9,2**	**1,2**	**55,91**	**0,03**
Obesity	12,64	0,58	132,06	0,09
Hemoperitoneum	**35,03**	**4,32**	**720,67**	**0,0011**
Gastrointestinal bleeding	2,07	0,1	12,97	0,54
VAA rupture at presentation	**12,39**	**2,36**	**91,1**	**0,0035**

Figure 3.—Factors associated with death after treatment for VAA. Hazard Ratios are age-adjusted.

TABLE VI.—*Review of the literature:reported mortality, morbidity and success rate after ET and OSR for the treatment of VAAs.*

Authors	ET				OSR			
	NR. VAA	Mortality rate	Complication rate	Success rate	NR. VAA	Mortality rate	Complication rate	Success rate
Kasirajan [9] (2001)	12	0%	0%	75%	0	-	-	-
Gabelmann [10] (2002)	25	4%	8.3%	92%	0	-	-	-
Muscari [11] (2002)	3	0%	33.3%	100%	26	0%	10%	100%
Sessa [12] (2004)	13	0%	23.1%	92.3%	27	11.1%	25.9%	100%
Dalainas [13] (2006)	4	0%	0%	100%	13	7.7%	0%	100%
Tulsyan [5] (2007)	48	8.3%	6%	98%	19	n.r.	n.r.	n.r.
Carroccio [14] (2007)	36	2.9%	25%	89%	0	-	-	-
Pulli [4] (2008)*	1	0%	0%	100%	49	2%	4.1%	100%
Grotemeyer [15] (2009)	2	0%	0%	100%	29	0%	23.8%	100%
Ferrero [8] (2011)	9	25%	25%	50%	24	4.1%	33.3%	100%
Piffaretti [16] (2011)	30	2.4%#	10.3%	96.6%	12	2.4%#	41.6%	100%
Marone [2] (2011)*	20	0%	10%	100%	56	1.8%	12.5%	100%
Spiliopoulos [17] (2011)	58	1.8%	3.7%	100%	0	-	-	-
Fankhauser [3] (2011)	185	6.2%	3%	98%	0	-	-	-
Balderi [1] (2011)*	26	0%	3.8%	100%	0	-	-	-
Our study (2012)	19	0%	5.2%	94.8%	13	7.6%	15.3%	100%

*Excluding renal artery aneurysms; #overall mortality rate, n.r.: not reported

affected artery and might be complicated by end-organ infarction (due to stent-graft thrombosis or distal embolization of small particles). Less frequently, a direct lesion of the vessel or even aneurysm rupture can cause bleeding, sometimes requiring emergent or late conversion to OSR.[17] Reported 30-day complication and mortality rates after ET in the literature ranged 0-33% and 0-25% respectively (Table VI). In our series, no deaths were recorded after ET. Migration of metal coils after transcatheter embolization has been described too, but they are a rare complication which can occur both at early or long-term.[18] None of these complications occurred in our series.

Furthermore, some authors reported high rates of recanalization of aneurysms which were previously excluded using ET.[19] Only one patient of our experienced this complication, which led to a repeated procedure with a stent graft deployment.

On the other hand, review of reported series on treatment of VAA using OSR (Table VI) revealed 30-day complication rates ranging from 10% [11] to 41.6% [16] and 30-day mortality rates of 0% [11] to 4.1%,[8] including both elective and emergent repair.

The 30-day mortality rate after OSR in our series was 8%, as only one patient died: this patient arrived in the emergency room with a massive hemoperitoneum and a hypovolemic shock. An immediate laparotomy was performed, but patient died during the attempt.

A review of published papers revealed that the mortality after VAA treatment depends on aneurysm location and comorbidity factors, as well as hemodynamic status of patients.[5] Regardless of surgical strategy, in our series a previous pancreatitis (HR=30, P=0.0006) and the presence of liver disease (HR=9.2, P=0.03) were significantly associated with a worse survival on Kaplan Meier curves. In addition, neoplasms and alcohol consumption more than 60 g/day in our analysis showed a trend towards an association (HR=6.9 and 5.1 respectively, both P=.06) with mortality. Most of all, a clinical presentation with hemoperitoneum or aneurysm rupture was associated with higher postoperative mortality (HR=35 and 12 respectively).

There are no specific risk factors for rupture described in the literature: even the diameter of the aneurysm (albeit intuitively correlated) has a relationship with rupture which is at least questionable, and for sure not a direct correlation as for AAAs.[11] In our series we observed this catastrophic complication both in VAA larger than 2 cm as well as in smaller ones. In our series the presence of pancreatitis in

patient's history was instead associated with clinical presentation of VAAs rupture, as well as alcohol consumption exceeding 60 gr/day. Abbas *et al*.[20] reported multiple aneurysms and non-atherosclerotic origin to be indipendant risk factors for rupture, specifically for hepatic artery aneurysms. Overall saccular aneurysms, VAAs equal or greater than 2 cm in diameter or growing rapidly and symptomatic aneurysms are thought to be more prone to rupture,[21] warranting some kind of treatment. However there is no general consensus on the other indications for treatment of VAA as the level of evidence is based upon expert opinions (Level of evidence C). It has also been suggested that all pseudoaneurysms should be treated regardless of their size, because they are more likely to rupture than true aneurysms.[10] The type of vessel affected indeed seems to be related to the risk for aneurysm rupture, as the event is most frequent in the hepatic artery (80%). Rupture of celiac trunk is the most dramatic event, with 100% deaths reported.[17]

According to these results, our policy is to treat aggressively most of VAAs.

Our study has several limitations. Due to the small number of patients and the retrospective design, we are unable to draw conclusions about risk factors for VAA rupture and 30-days mortality. The literature also lacks a third group of patients (usually those who refused or were refused for treatment) to better understand the natural history of the disease, in terms of risk of rupture and mortality.

Despite the remarkable progress made in diagnostic techniques and therapeutic methods over the years, the management of patients with VAAs still remains challenging. We believe that elective intervention with ET, when clinical and anatomical conditions are favorable, can be a valid alternative to OSR for the treatment of VAAs, being minimally invasive for the patients, although not completely free from risk. On the other hand, we must remember that anytime ET feasibility is at least questionable, OSR offers both immediate and long term positive results, ensuring a long-lasting patency and a good organ perfusion.

Conclusions

Clinical presentation, location of the aneurysm, as well as patients' operative risk are the factors that mainly influence surgical strategy. Both OSR and ET offered in our experience a safe way to treat VAAs. ET was associated with shorter in-hospital stay and shorter procedure time compared to OSR.

The presence of pancreatitis and a daily alcohol consumption exceeding 60 g were more frequent in patients who presented with VAAs rupture. A history of pancreatitis and liver cirrhosis were significantly associated with mortality, while a weak association was found between the presence of alcohol consumption or previous cancer and mortality. Clinical presentation with hemoperitoneum or aneurysm rupture were associated with higher risk of mortality, regardless of the type of treatment.

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