Surgical treatment of visceral artery aneurysms: A 25-year experience

Surgical treatment of visceral artery aneurysms: A 25-year experience

Raffaele Pulli, MD,[a] Walter Dorigo, MD,[a] Nicola Troisi, MD,[a] Giovanni Pratesi, MD,[b] Alessandro Alessi Innocenti, MD,[a] and **Carlo Pratesi, MD,[a]** *Florence and Rome, Italy*

Objective: **The aim of this study was to analyze our 25-year experience with surgical treatment of visceral artery aneurysms (VAAs), with particular attention paid to early and long-term results.**

Materials and Methods: **From January 1982 to September 2007, 55 patients (32 males, 58%, and 23 females, 42%) underwent surgical treatment of 59 VAAs. Only one patient was treated with an endovascular procedure. Mean patient age was 59.3 years (range, 36-78 years). The site of aneurysmal disease was splenic artery in 30 (50.8%) cases, renal artery in nine (15.2%) cases, common hepatic artery in seven (11.9%) cases, pancreaticoduodenal artery in four (6.8%) cases, celiac trunk in three (5.1%) cases, superior mesenteric artery in two (3.4%) cases, and gastroduodenal, inferior mesenteric, middle colic and right gastroepiploic in one (1.7%) case for each artery. Two (3.6%) patients had multiple VAAs. In five (9.1%) patients, an abdominal aortic aneurysm coexisted. Early results in terms of mortality and major complications were assessed. Follow-up consisted of clinical and ultrasound examinations at 1 and 12 months, and yearly thereafter. Long-term results in terms of survival and aneurysm-related complications were analyzed.**

Results: **In all but two cases, elective intervention in asymptomatic patients was performed. Two (3.6%) patients had a ruptured aneurysm (one pancreaticoduodenal artery and one middle colic artery). The one perioperative death was due to an acute pancreatitis in a patient operated on for a giant inflammatory splenic artery aneurysm, yielding a perioperative mortality rate of 1.8%. Two major complications (retroperitoneal hematoma and acute pancreatitis) were recorded. Mean duration of follow-up was 82.1 months (range, 0-324 months). Estimated 10-year survival rate was 79.5%. During follow-up two aneurysm-related complications occurred, with an estimated 10-year, aneurysm-related, complication-free survival rate of 75.2%.**

Conclusion: **In the era of minimally invasive therapeutic approaches, elective open surgical treatment of visceral artery aneurysms is safe and effective, and offers satisfactory early and long-term results. (J Vasc Surg 2008;48:334-42.)**

Aneurysmal disease of the visceral arteries is a relatively uncommon yet potentially catastrophic condition.[1-5] Visceral artery aneurysms (VAAs) include renal and splanchnic lesions. Renal aneurysms have a low incidence rate in the general population (0.01%-0.09%),[6] whereas the incidence of splanchnic aneurysms ranges from 0.1% to 2%.[1-3,7] In the splanchnic aneurysm group, the splenic artery is the most common site of aneurysmal disease (60%), followed by the hepatic arteries (20%), celiac trunk (5.5%), superior mesenteric artery (4%), gastric and gastroepiploic arteries (4%), intestinal arteries (3%), pancreaticoduodenal arteries (2%), gastroduodenal artery (1.5%), and the inferior mesenteric artery (<1%).

In part because of their rarity, no strong consensus exists in the literature concerning the indications for treatment of VAAs. Although the natural history of VAAs is largely unknown, rupture occurs frequently when the maximum aneurysmal diameter exceeds 2 cm, which is the current generally accepted threshold for treatment of asymptomatic lesions.[1,4-6,8] Open surgical repair provides satisfactory perioperative results, particularly in elective cases; however, there is a paucity of data concerning long-term outcome.[9-13]

The purpose of this study was to retrospectively evaluate early and long-term results of our 25-year experience with surgical treatment of VAAs.

MATERIALS AND METHODS

From January 1982 to September 2007, 3105 open and endovascular interventions for abdominal aneurysms were performed at our institution. Data concerning all interventions including preoperative, intraoperative, and postoperative variables were prospectively collected in a dedicated database. A post hoc analysis of this database performed to identify all the patients operated on for visceral artery aneurysms identified 55 patients. All hospital charts for these patients as well as the database analysis were reviewed. Preoperative variables included demographic data, risk factors, comorbid conditions, and clinical and anatomic features. Intraoperative data collected included surgical approach, type of reconstruction, and associated procedures. Postoperative data included clinical events and follow-up.

Once the VAA was diagnosed and the indication for treatment was noted, preoperative diagnostic workup consisted of a computed tomography (CT) scan and, in selected patients, digital subtraction angiography. Early results in terms of mortality and major complications (defined as surgery-related complications requiring reintervention or a longer hospital stay) were assessed and reported on the

From the Department of Vascular Surgery, University of Florence,[a] and the Department of Vascular Surgery, University of Rome, Tor Vergata.[b]

Competition of interest: none.

Reprint requests: Raffaele Pulli, MD, Department of Vascular Surgery, University of Florence, Viale Morgagni 85, 50134, Florence, Italy (e-mail: rpulli@unifi.it).

0741-5214/$34.00

doi:10.1016/j.jvs.2008.03.043

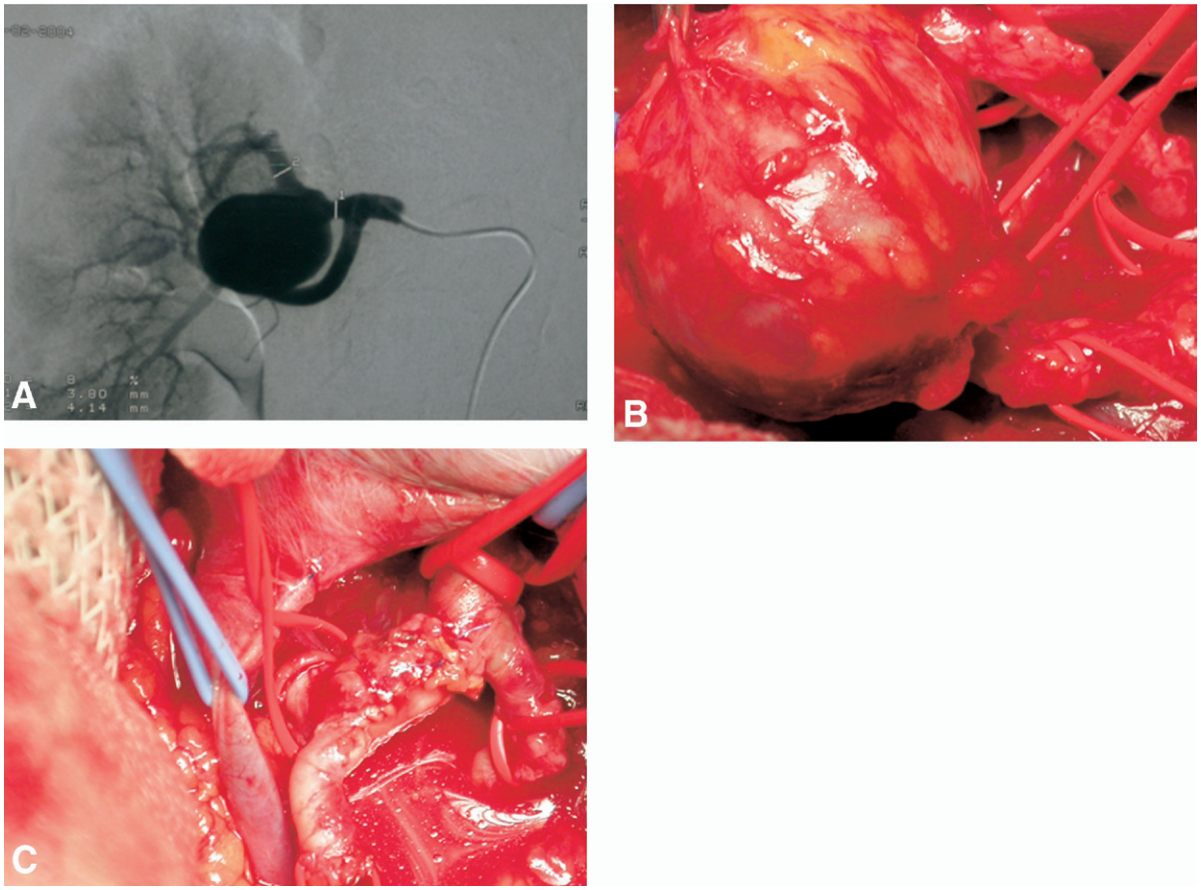

Fig 1. Giant aneurysm of the right renal artery. **A,** Preoperative selective angiography. **B,** Intraoperative finding. **C,** Aneurysmal resection with primary closure.

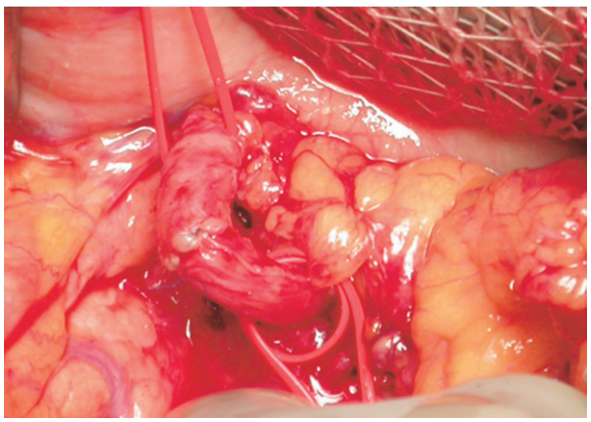

Fig 2. Splenic artery aneurysm. Aneurysmal resection with end-to-end anastomosis.

basis of aneurysm location. Follow-up consisted of clinical and ultrasound scan examinations at 1 and 12 months, and yearly thereafter. All patients had at least one CT scan during follow-up.

Long-term results were analyzed in terms of survival and absence of aneurysm-related complications with Kaplan-Meier curves.

RESULTS

Study group

Patients were predominantly male (32/55, 58%), with a mean age of 59.3 years (range, 36-78 years). Indications for surgical treatment included a maximum aneurysm diameter greater than 2 cm in asymptomatic patients, and symptomatic lesions regardless of the diameter.

The site of aneurysmal disease was splenic artery in 30 (50.8%) cases, renal artery in nine (15.2%) cases, common hepatic artery in seven (11.9%) cases, pancreaticoduodenal artery in four (6.8%) cases, celiac trunk in three (5.1%) cases, superior mesenteric artery in two (3.4%) cases, and gastroduodenal, inferior mesenteric, middle colic and right gastroepiploic all in one (1.7%) case each. Two (3.6%) patients had multiple VAAs, which were simultaneously treated: In one patient, a renal artery aneurysm was associated with a pancreaticoduodenal artery aneurysm (renal aneurysm treated first), whereas in the other patient four

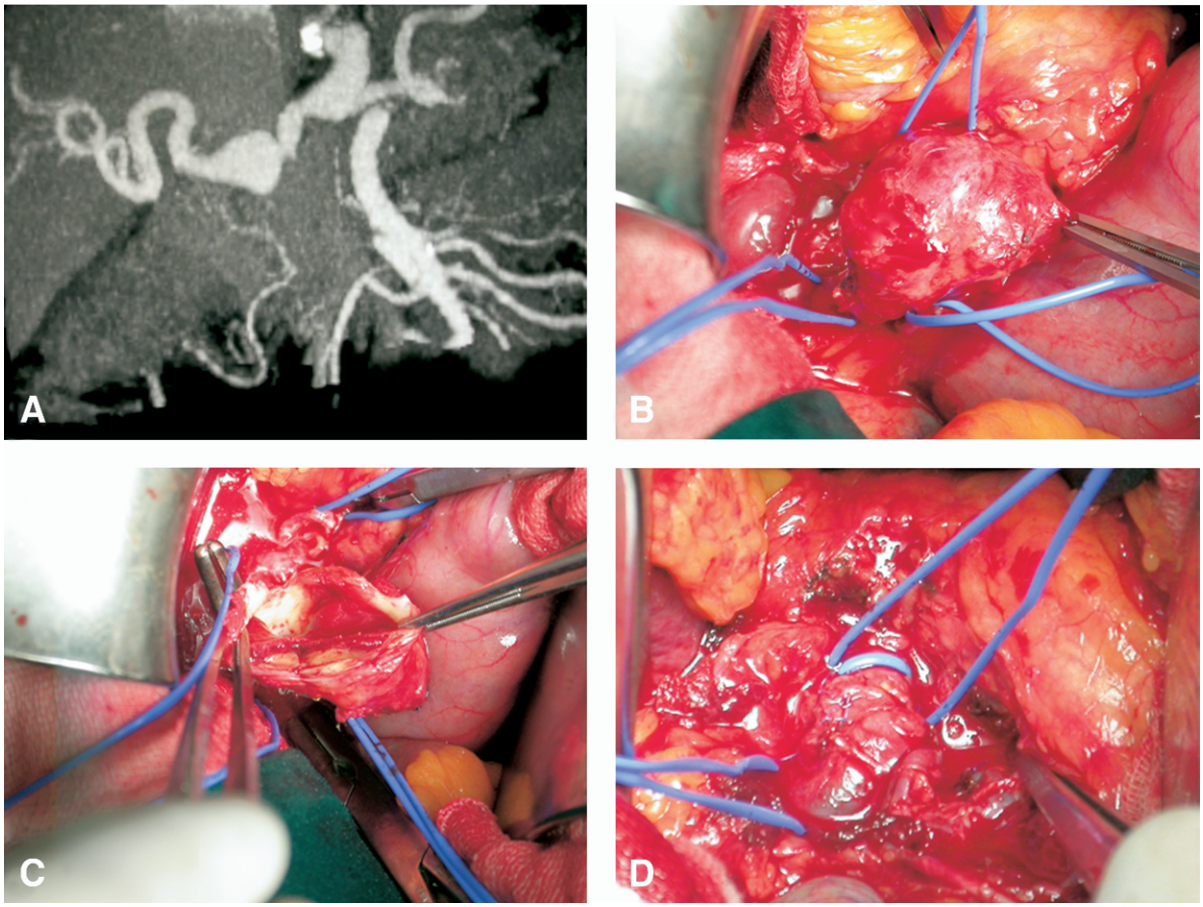

Fig 3. Common hepatic artery aneurysm. **A,** Preoperative angio-CT scan. **B,** Intraoperative finding. **C,** Aneurysmal opening and resection. **D**, Primary closure of the hepatic artery.

synchronous aneurysmal localizations (celiac trunk, common hepatic artery, splenic artery, right gastroepiploic artery, treated in this order) were present.

In 52 (94.6%) patients, the diagnosis was incidentally made during examinations performed for unrelated abdominal diseases; in all these patients no specific symptoms were present. In one patient with a giant splenic artery aneurysm, the diagnosis was suggested by an evident pulsatile abdominal mass on physical examination. The remaining two (3.6%) patients had abdominal pain associated with acute anemia; CT scan demonstrated the presence of a contained ruptured aneurysm of the pancreaticoduodenal and middle colic arteries, respectively, and urgent intervention was performed in both cases.

Five patients (four with renal artery aneurysms and one with a superior mesenteric artery aneurysm) had a concomitant abdominal aortic aneurysm, which in all cases was repaired first during the same operation. In one patient with a splenic artery aneurysm, a benign pheochromocytoma coexisted. Sixteen of seventeen females operated on for a splenic artery aneurysm were multiparas.

Early results

Renal artery aneurysms. Nine patients were operated on for renal artery aneurysm (seven males, 78%, and two females, 22%), with a mean aneurysm diameter of 2.7 cm. Four of nine patients had arterial hypertension; however, no renal insufficiency was noted. An abdominal aortic aneurysm coexisted in four (44.5%) patients. Different surgical approaches were used in these patients. A prosthetic aortorenal bypass was performed in the four patients simultaneously treated for abdominal aortic aneurysm. In the five patients with isolated renal aneurysms, aneurysmectomy with end-to-end anastomosis was carried out in three cases, aneurysm resection with saphenous vein patch closure was performed in one case, and aneurysmorrhaphy was performed in one patient with a distal aneurysm location (Fig 1). No perioperative deaths or major complications occurred.

Splenic artery aneurysms. Thirty patients were operated on for splenic artery aneurysms. Splenic aneurysms were saccular in 26 cases with a mean diameter of 4.3 cm. Aneurysmal degeneration of the entire artery was present in

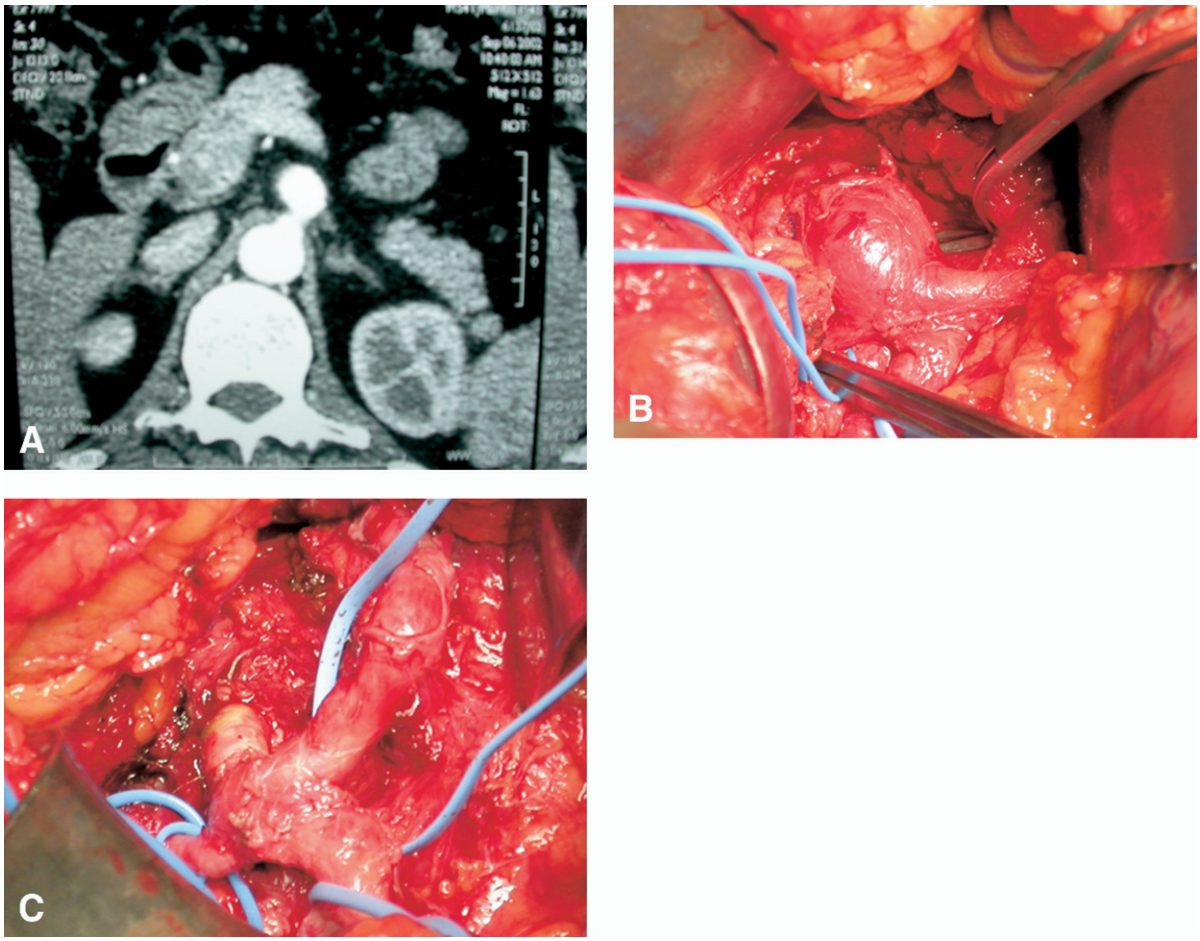

Fig 4. Aneurysm of the celiac trunk. **A,** Preoperative angio-CT scan. **B,** Intraoperative finding. **C,** Primary closure of the celiac trunk.

one case (cirsoid aneurysm); the remaining three patients had a giant aneurysm, with a maximum diameter greater than 6 cm.

The aneurysm was completely resected in 28 cases. In 22 cases the splenic artery was reconstructed with an end-to-end anastomosis (Fig 2), whereas in five patients the distal location of the aneurysm required splenectomy. In one case a partial aneurysmectomy with proximal and distal ligation of the splenic artery without splenectomy was performed, and one patient underwent aneurysmorrhaphy. In the remaining patient with a giant aneurysm involving pancreatic parenchyma, an endovascular procedure via a right transfemoral approach using a balloon-expandable polytetrafluoroethylene-covered stent was performed.

Histopathologic examination of the aneurysm wall demonstrated typical atherosclerotic lesions in 15 (50%) cases and fibrodysplasia in 13 (43.3%) cases, and typical changes associated with an inflammatory aneurysm were noted in one case.

One death due to acute pancreatitis occurred in the perioperative period in a patient operated on for a giant inflammatory aneurysm without a prior history of pancreatitis. This was the only perioperative death in the entire study group, for an overall 30-day mortality rate of 1.8%. One patient developed a large retroperitoneal hematoma on the second postoperative day, which at exploration was drained with no evidence of active bleeding. The patient was given fresh plasma derivatives, and a follow-up CT on the fourth postoperative day demonstrated nearly complete hematoma reabsorption. An additional patient was readmitted on the seventh postoperative day for persistent abdominal pain; a CT scan demonstrated the presence of peripancreatic effusion without a significant increase in pancreatic amylase. The patient was medically treated with antibiotics and pancreatic inhibitors, with complete resolution of symptoms and CT findings.

Hepatic artery aneurysms. Six males and one female underwent elective surgical treatment for hepatic artery aneurysms. One patient had multiple VAAs. In all cases the aneurysm was located in the common hepatic artery. Isolated aneurysmectomy was performed in three cases (Fig 3), aneurysmectomy and patching with autologous vein in

Table. Intraoperative data and early results

Site	*No. of lesions*	*Kind of intervention*	*Perioperative mortality*	*Peroperative major complications*
Splenic artery	30	Resection with end-to-end anastomosis (22) Splenectomy and ligature (5) Aneurysmorrhaphy (1) Partial resection with arterial ligature (1) Endovascular exclusion (1)	1 (3.3%)	2 (6.6%)
Renal artery	9	Aortorenal bypass (4) Resection with end-to-end anastomosis (3) Resection and patch closure (1) Aneurysmorrhaphy (1)	—	—
Hepatic artery	7	Aneurysmectomy and primary closure (3) Aneurysmectomy and arterial ligation (2) Aneurysmectomy and patch closure (1) Aneurysmorrhaphy (1)	—	—
Celiac trunk and mesenteric arteries	6	Resection and tube graft (3) Aneurysmectomy and primary closure (2) Aneurysmectomy and patch closure (1)	—	—
Peripancreatic arteries	5	Aneurysmectomy with end-to-end anastomosis (5)	—	—
Gastric and bowel arteries	2	Aneurysmectomy and patch closure (1) Aneurysmectomy and primary closure (1)	—	—

one case, and aneurysmorrhaphy in one case. In the remaining two patients, partial aneurysmectomy with proximal and distal ligation of the common hepatic artery was performed. In one of these two cases, blood supply from the gastroduodenal artery was inadequate and prosthetic splenohepatic bypass was carried out. No adverse events occurred in the perioperative period.

Aneurysms of celiac trunk and mesenteric arteries. In this subgroup, six patients were operated on (five males and one female). Three patients had involvement of the celiac trunk (in one case the patient had multiple VAAs). Two patients had an aneurysm of the superior mesenteric artery and one patient an aneurysm of the inferior mesenteric artery. One of the two patients with an aneurysm of the superior mesenteric artery had a concomitant abdominal aortic aneurysm, whereas an inflammatory aneurysm was detected in the other patient at pathological examination.[14]

In three patients, the aneurysm was opened and repaired with an interposition tube graft in a fashion similar to that used to repair aortic aneurysms, in two cases isolated aneurysmectomy was performed (Fig 4), and the remaining patient had aneurysmectomy and patching with saphenous vein. No deaths or major complications occurred in the perioperative period.

Aneurysms of peripancreatic arteries. Four aneurysms of the posterosuperior pancreaticoduodenal artery and one aneurysm of the gastroduodenal artery were surgically repaired. All patients were female. One patient with a pancreaticoduodenal aneurysm had a concomitant renal artery aneurysm. One patient was operated on for a ruptured lesion. One young female with a large pancreaticoduodenal aneurysm had an extrinsic compression of celiac trunk by the median arcuate ligament, which was resected.

In all the cases aneurysmectomy with end-to-end anastomosis was performed. There were no deaths or complications in the perioperative period.

Aneurysms of gastric and intestinal arteries. Two male patients underwent surgical treatment of a ruptured middle colic artery aneurysm and of a right gastroepiploic artery, respectively. The middle colic artery was repaired with aneurysmectomy and patch closure with autologous vein, whereas the gastroepiploic artery (in a patient with multiple VAAs) was repaired with isolated aneurysmectomy. No perioperative deaths or major complications occurred.

Overall intraoperative data and early results are presented in the table.

Long-term results

Follow-up was available in 49 (89.1%) patients, with a mean duration of 82.1 months (range, 0-324 months). Five patients were lost to follow-up. During follow-up six deaths occurred, with an estimated 1-, 5- and 10-year survival rates of 98%, 98%, and 79.5%, respectively (Fig 5). There were no aneurysm-related deaths. The cause of death was cancer in three patients; in the other three cases, acute myocardial infarction (two patients) and massive gastric bleeding from peptic ulcer (one patient) occurred. Aneurysm-related complications occurred in two patients.

A 38-year-old female with a fibrodysplastic renal artery aneurysm was treated with aneurysm resection and patch closure, but at 2 months she developed severe arterial hypertension unresponsive to medical treatment. Duplex ultrasound scan and CT angiography demonstrated a high-grade stenosis of a branch of the operated renal artery. The lesion was treated with percutaneous transluminal angio-

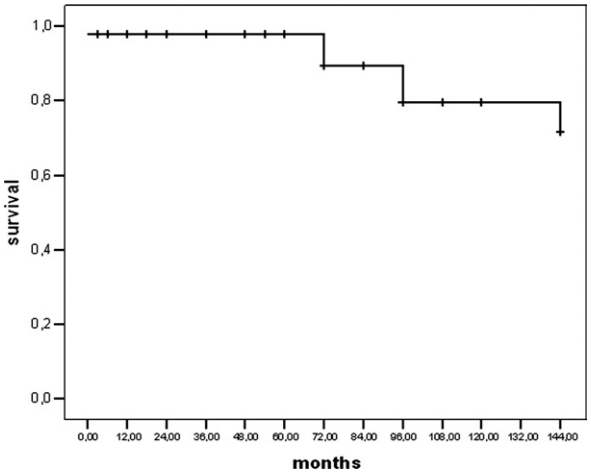

Fig 5. Long-term survival (Kaplan-Meier curve with number of patients at risk and SE values).

plasty and stenting, with complete recovery of symptoms without the need for further antihypertensive medical treatment.

Another young female operated on for a fibrodysplastic splenic artery aneurysm developed a limited, asymptomatic splenic infarction, which was detected 1 year postoperatively during a routine CT scan in the presence of normal patency of the reconstructed splenic artery.

Cumulative estimated 1-, 5- and 10-year, aneurysm-related, complication-free survival rates were 95.9%, 93.7%, and 75.2%, respectively (Fig 6).

One patient was operated on for rectal cancer 10 years postoperatively; two patients (one operated on for splenic artery aneurysm and the other for renal artery aneurysm) underwent surgical intervention for abdominal aortic aneurysm at 10 and 11 years, respectively, whereas another patient underwent urgent successful intervention for a type A aortic dissection 15 years postoperatively. Another pa-

Months	0	12	24	36	48	60	72	84	96	108	120
Patients (no. at risk)	48	45	40	35	31	27	22	18	17	12	10
SE (%)	2	2	2	2	2	2	2	6	6	8.5	8.5

	Months	*Event*	*Estimated percentage*	*Standard error*	*Cumulative events*	*Patients at risk*
1	0.000	1.00	0.980	0.020	1	48
2	3.000	0.00			1	47
3	6.000	0.00			1	46
4	12.000	0.00			1	45
5	12.000	0.00			1	44
6	12.000	0.00			1	43
7	12.000	0.00			1	42
8	18.000	0.00			1	41
9	24.000	0.00			1	40
10	24.000	0.00			1	39
11	24.000	0.00			1	38
12	24.000	0.00			1	37
13	24.000	0.00			1	36
14	36.000	0.00			1	35
15	36.000	0.00			1	34
16	36.000	0.00			1	33
17	36.000	0.00			1	32
18	48.000	0.00			1	31
19	48.000	0.00			1	30
20	48.000	0.00			1	29
21	54.000	0.00			1	28
22	60.000	0.00			1	27
23	60.000	0.00			1	26
24	60.000	0.00			1	25
25	60.000	0.00			1	24
26	60.000	0.00			1	23
27	72.000	1.00			2	22
28	72.000	1.00	0.894	0.060	3	21
29	72.000	0.00			3	20
30	72.000	0.00			3	19
31	84.000	0.00			3	18
32	96.000	1.00			4	17
33	96.000	1.00	0.795	0.085	5	16
34	96.000	0.00			5	15
35	96.000	0.00			5	14
36	96.000	0.00			5	13
37	108.000	0.00			5	12
38	108.000	0.00			5	11
39	120.000	0.00			5	10

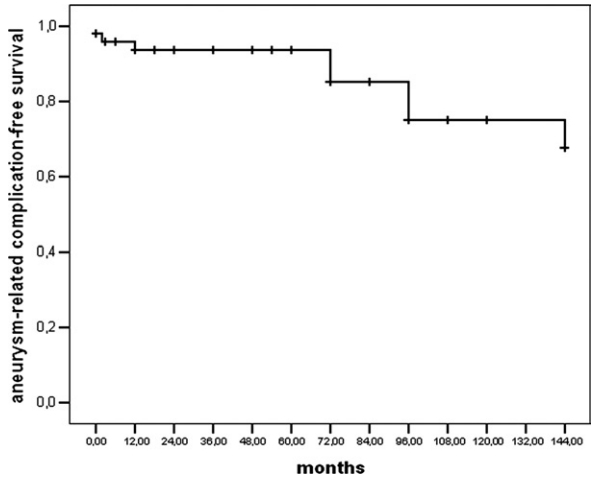

Fig 6. Long-term, aneurysm-related, complication-free survival (Kaplan-Meier curve with number of patients at risk and SE values).

tient underwent carotid endarterectomy 3 years postoperatively. Finally, one patient developed a small ascending aortic aneurysm, which is still under follow-up.

DISCUSSION

The pathophysiology of VAAs is still incompletely understood and each aneurysmal location presents its own unique features. Atherosclerosis seems to play a secondary role in the development of these lesions and does not always represent the first pathologic mechanism.[15-21] Association with abdominal aortic aneurysm is rarely described, which was also our finding.

The natural history of untreated VAAs remains unclear.[21-23] These aneurysms seem to have a slow growing progression, with a diameter-related risk of rupture; however, most reports in the literature are retrospective surgical studies that describe patients who have undergone surgical intervention.

Months	0	12	24	36	48	60	72	84	96	108	120
Patients (no. at risk)	48	43	38	33	29	26	21	17	16	12	10
SE (%)	2	2.9	3.5	3.5	3.5	3.5	3.5	6.6	6.6	8.8	8.8

	Months	*Event*	*Estimated percentage*	*Standard error*	*Cumulative events*	*Patients at risk*
1	0.000	1.00	0.980	0.020	1	48
2			0.000	0.00	1	47
3	2.000	1.00	0.959	0.029	2	46
4	3.000	0.00			2	45
5	6.000	0.00			2	44
6	12.000	1.00	0.937	0.035	3	43
7	12.000	0.00			3	42
8	12.000	0.00			3	41
9	12.000	0.00			3	40
10	18.000	0.00			3	39
11	24.000	0.00			3	38
12	24.000	0.00			3	37
13	24.000	0.00			3	36
14	24.000	0.00			3	35
15	24.000	0.00			3	34
16	36.000	0.00			3	33
17	36.000	0.00			3	32
18	36.000	0.00			3	31
19	36.000	0.00			3	30
20	48.000	0.00			3	29
21	48.000	0.00			3	28
22	54.000	0.00			3	27
23	60.000	0.00			3	26
24	60.000	0.00			3	25
25	60.000	0.00			3	24
26	60.000	0.00			3	23
27	60.000	0.00			3	22
28	72.000	1.00			4	21
29	72.000	1.00	0.852	0.066	5	20
30	72.000	0.00			5	19
31	72.000	0.00			5	18
32	84.000	0.00			5	17
33	96.000	1.00			6	16
34	96.000	1.00	0.752	0.088	7	15
35	96.000	0.00			7	14
36	96.000	0.00			7	13
37	108.000	0.00			7	12
38	108.000	0.00			7	11
39	120.000	0.00			7	10

In recent years, the widespread use of noninvasive imaging has made early diagnosis in asymptomatic patients more frequent, reducing the risk of rupture and allowing the treatment of a large number of asymptomatic lesions. Once the diagnosis is made, the indications for treatment of asymptomatic VAAs remain controversial because of the lack of prospective studies evaluating the natural history of these lesions. As is our policy, there is a current general consensus for the need to treat asymptomatic VAAs greater than 2 cm and symptomatic ones regardless of size.[1,3,6,8,22] The choice of surgical technique is dictated by the involved artery, the localization of the aneurysm, the surgeon's experience, and the urgency of intervention (emergent or elective).

In patients with renal artery aneurysms, the site of the lesion and its morphology are the factors that mainly affect surgical strategy. Saccular lesions limited to the proximal renal artery may be treated with aneurysmectomy and patching or end-to-end anastomosis, whereas aneurysms of the mid or distal renal artery are usually repaired with prosthetic bypass graft,[6,24] as was our strategy. In complex cases (multiple or intraparenchymal aneurysms) ex vivo repair of the kidney represents an alternative approach,[25] reserving nephrectomy for only limited and highly select cases.

Splenectomy was the most common operation in the past in patients with splenic artery aneurysms[26]; however, several studies have highlighted the importance of splenic preservation[9] to prevent infectious complications in the perioperative period. Splenic artery aneurysms are often saccular and localized in the proximal or middle third of the artery; for this reason aneurysmectomy with end-to-end anastomosis can be safely performed with preservation of the spleen.[8,21,27] In our experience, we used this approach most often. An alternative approach is simple ligation of the splenic artery, considering that blood supply can be maintained through the short gastric arteries; we used this approach in one of the three giant aneurysms, without signs of ischemic lesions of the spleen in the perioperative period and during follow-up. However, as vascular surgeons, we believe that, whenever possible, an end-to-end anastomosis is quite simple and does not affect the safety of the intervention. In the presence of hilar and intraparenchymal aneurysm location, surgical reconstruction of the artery can be impossible and splenectomy unavoidable, as in five cases of our series.

Similar surgical strategies can be adopted for the treatment of hepatic artery aneurysms.[8] Proximal and distal ligation of the hepatic artery provides a low-risk solution; however, evaluation of the blood supply provided by the gastroduodenal artery on the basis of the color changes of the liver parenchyma is crucial.[28] In our experience one patient required splenohepatic bypass after ligation of the proximal common hepatic artery. When a simple ligation is not possible, aneurysmectomy with reconstruction of the artery is mandatory. In some cases of distal or intraparenchymal lesions, a resection of the involved liver parenchyma may be required.

In patients with mesenteric and celiac aneurysms, surgical techniques range from simple ligation to anterograde bypass from the aorta.[29] In our series, we did not adopt these techniques and instead preferred to restore the patency of the involved artery in all the cases, thus preserving all the collateral vessels near the aneurysm.[14]

Finally, for gastric, intestinal, and peripancreatic aneurysms, which interestingly were more common in our series than in previously reported studies, surgical treatment often consists of ligation of the artery or resection of the aneurysm with end-to-end anastomosis.[21,30] In our series, we always reconstructed the continuity of the artery.

The adoption of adequate surgical strategy in patients with VAAs results in low perioperative mortality and morbidity rates (0%-5%) after elective surgery.[3,6-12,31] Also in our experience early results were excellent, with 30-day mortality and combined mortality and morbidity rates of 1.8% and 5.4%, respectively. Interestingly, all perioperative major complications occurred in patients operated on for splenic artery aneurysm. This type of aneurysm represented the largest subgroup of patients in our series, which may have influenced our results. Moreover, particularly in the presence of large aneurysms located in the middle and distal part of the artery, the dissection of the lesion can be difficult and the risk of pancreatic and splenic injuries can be substantial.

Long-term results of surgical treatment of VAAs were associated with high survival rates and a low incidence of aneurysm-related complications, confirming the excellent durability of a surgical approach in these patients. No aneurysm-related deaths occurred and only two aneurysm-related complications were recorded during follow-up, with one case being completely asymptomatic. Furthermore, the need for reintervention was limited to one case, suggesting the curative role of surgical intervention in these patients.

Recently, two promising new options have emerged: the endovascular approach with coil embolization or stent-graft repair and the laparoscopic treatment with arterial ligation.[32-35] Selective catheterization of the involved artery and embolization of the aneurysm by coils have been proposed in high-risk patients and for the treatment of ruptured VAAs.[32,33] However, our two cases of urgent intervention for aneurysmal rupture occurred in 1983 and 1998, respectively, largely before the introduction of endovascular surgery in our department. Moreover, the risk of coil embolization resulting in incomplete exclusion of the aneurysm has been reported in the literature[32]; this finding has caused us to take a cautious approach to routinely applying this technique. Stent-graft repair could be particularly used for the treatment of aneurysms when the surrounding structures are involved[34]; in our series we used this approach in one patient with a giant splenic artery aneurysm located inside the pancreatic parenchyma and at high risk of postoperative pancreatitis. In our opinion, an endovascular approach may be reserved for such select patients, considering that the frequent tortuosity and redundancy of visceral vessels make endovascular repair more

difficult and that the mean age of these patients is relatively young, making them a low surgical risk. Laparoscopic operations have been proposed for the treatment of splenic artery aneurysms[35]; however, we did not have experience with this surgical approach in our series.

CONCLUSIONS

Elective surgical treatment of asymptomatic VAAs larger than 2 cm is safe and effective, with low perioperative mortality and morbidity. In long-term follow-up, surgical repair is extremely durable with few aneurysm-related complications. Results for alternative therapeutic approaches should be compared with those of open surgical repair.

AUTHOR CONTRIBUTIONS

Conception and design: RP, WD, NT, CP
Analysis and interpretation: RP, WD
Data collection: NT, WD
Writing the article: RP, WD, NT, CP
Critical revision of the article: CP, RP, WD
Final approval of the article: CP, RP, AA
Statistical analysis: NT, WD
Obtained funding: not applicable
Overall responsibility: CP, RP, WD, NT, GP, AA

REFERENCES

1. Stanley JC, Wakefield TW, Graham LM, Whitehouse WM Jr, Zelenock GB, Lindenauer SM. Clinical importance and management of splanchnic aneurysms. J Vasc Surg 1986;3:836-40.
2. Zelenock GB, Stanley JC. Splanchnic artery aneurysms. In: Rutherford RB, editor. Vascular surgery. 5th ed. Philadelphia: WB Saunders; 2000. p. 1369-82.
3. Carr SC, Pearce WH, Vogelzang RL, McCarthy WJ, Nemcek AA Jr, Yao JS. Current management of visceral artery aneurysms. Surgery 1996;120:627-33.
4. Carr SC, Mahvi DM, Hoch JR, Archer CW, Turnipseed WD. Visceral artery aneurysm rupture. J Vasc Surg 2001;33:806-11.
5. Wagner WH, Allins AD, Treiman RL, Cohen JL, Foran RF, Levin PM, et al. Ruptured visceral artery aneurysms. Ann Vasc Surg 1997;11:342-7.
6. Eskandari MK, Resnick SA. Aneurysms of the renal artery. Semin Vasc Surg 2005;18:202-8.
7. Carmeci C, McClenathan J. Visceral artery aneurysms as seen in a community hospital. Am J Surg 2000;179:486-9.
8. Berceli SA. Hepatic and splenic artery aneurysms. Semin Vasc Surg 2005;18:196-201.
9. Pulli R, Alessi Innocenti A, Barbanti E, Dorigo W, Turini F, Gatti M, et al. Early and long-term results of surgical treatment of splenic artery aneurysms. Am J Surg 2001;182:520-3.
10. Grego FG, Lepidi S, Ragazzi R, Iurilli V, Stramanà R, Deriu GP. Visceral artery aneurysms: a single center experience. Cardiovasc Surg 2003;11:19-25.
11. Sessa C, Tinelli G, Porcu P, Aubert A, Thony F, Magne JL. Treatment of visceral artery aneurysms: description of a retrospective series of 42 aneurysms in 34 patients. Ann Vasc Surg 2004;18:695-703.
12. Chiesa R, Astore D, Guzzo G, Frigerio S, Tshomba Y, Castellano R, et al. Visceral artery aneurysms. Ann Vasc Surg 2005;19:42-8.
13. Abbas MA, Stone WM, Fowl RJ, Gloviczki P, Oldenburg WA, Pairolero PC, et al. Splenic artery aneurysms: two decades experience at Mayo clinic. Ann Vasc Surg 2002;16:442-9.
14. Dorigo W, Pulli R, Alessi Innocenti A, Anichini C, Azas L, Barbanti E, et al. Isolated inflammatory aneurysm of superior mesenteric artery: unexpected pathologic diagnosis. J Vasc Surg 2004;39:903-5.
15. Cormier F, Cormier JM. Thirty-eight cases of dysplasia of the superior mesenteric artery. J Mal Vasc 2005;30:150-61.
16. Kojima A, Shindo S, Kubota K, Iyori K, Ishimoto T, Kobayashi M, et al. Successful surgical treatment of a patient with multiple visceral artery aneurysms due to fibromuscular dysplasia. Cardiovasc Surg 2002;10:157-60.
17. Parfitt J, Chalmers RT, Wolfe JH. Visceral aneurysms in Ehlers-Danlos syndrome: case report and review of the literature. J Vasc Surg 2000;31:1248-51.
18. Serafino G, Vroegindeweij D, Boks S, van der Harst E. Mycotic aneurysm of the celiac trunk: from early CT sign to rupture. Cardiovasc Intervent Radiol 2005;28:677-80.
19. Settmacher U, Nussler NC, Pfitzmann R, Heise M, Neuhaus P. Surgical treatment of a post-traumatic hepatic artery aneurysm. Eur J Vasc Endovasc Surg 2001;21:77-8.
20. Hunsaker DM, Turner S, Hunsaker JC 3rd. Sudden and unexpected death resulting from splenic artery aneurysm rupture: two case reports of pregnancy-related fatal rupture of splenic artery aneurysm. Am J Forensic Med Pathol 2002;23:338-41.
21. Ducasse E, Roy F, Chevalier J, Massouille D, Smith M, Speziale F, et al. Aneurysm of the pancreaticoduodenal arteries with a celiac trunk lesion: current management. J Vasc Surg 2004;39:906-11.
22. Abbas MA, Fowl RJ, Stone WM, Panneton JM, Oldenburg WA, Bower TC, et al. Hepatic artery aneurysms: factors that predict complications. J Vasc Surg 2003;38:41-5.
23. McClenathan JH. Abdominal pain caused by thrombosis of a gastroepiploic artery aneurysm—a case report. Vasc Endovascular Surg 2005;39:371-3.
24. Pfeiffer T, Reiher L, Grabitz K, Grünhage B, Häfele S, Voiculescu A, et al. Reconstruction for renal artery aneurysm: operative techniques and long-term results. J Vasc Surg 2003;37:293-300.
25. English WP, Pearce JD, Craven TE, Wilson DB, Edwards MS, Ayerdi J, et al. Surgical management of renal artery aneurysms. J Vasc Surg 2004;40:53-60.
26. Trastek VF, Pairolero PC, Joyce JW, Hollier LH, Bernatz PE. Splenic artery aneurysms. Surgery 1982;91:694-9.
27. de Perrot M, Buhler L, Deleaval J, Borisch B, Mentha G, Morel P. Management of true aneurysms of the splenic artery. Am J Surg 1998;175:466-8.
28. Lumsden AB, Mattar SG, Allen RC, Bacha EA. Hepatic artery aneurysms: the management of 22 patients. J Surg Res 1996;60:345-50.
29. Stone WM, Abbas M, Cherry KJ, Fowl RJ, Gloviczki P. Superior mesenteric artery aneurysms: is presence an indication for intervention? J Vasc Surg 2002;36:234-7.
30. Moore E, Matthews MR, Minion DJ, Quick R, Schwarcz TH, Loh FK, et al. Surgical management of peripancreatic arterial aneurysms. J Vasc Surg 2004;40:247-53.
31. Huang YK, Hsieh HC, Tsai FC, Chang SH, Lu MS, Ko PJ. Visceral artery aneurysm: risk factor analysis and therapeutic opinion. Eur J Vasc Endovasc Surg 2007;33:293-301.
32. Tulsyan N, Kashyap VS, Greenberg RK, Sarac TP, Clair DG, Pierce G, et al. The endovascular management of visceral artery aneurysms and pseudoaneurysms. J Vasc Surg 2007;45:276-83.
33. Saltzberg SS, Maldonado TS, Lamparello PJ, Cayne NS, Nalbandian MM, Rosen RJ, et al. Is endovascular therapy the preferred treatment for all visceral artery aneurysms? Ann Vasc Surg 2005;19:507-15.
34. Larson RA, Solomon J, Carpenter JP. Stent graft repair of visceral artery aneurysms. J Vasc Surg 2002;36:1260-3.
35. Reardon PR, Otah E, Craig ES, Matthews BD, Reardon MJ. Laparoscopic resection of splenic artery aneurysms. Surg Endosc 2005;19:488-93.

Submitted Nov 15, 2007; accepted Mar 22, 2008.