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Visceral Artery Aneurysm: Risk Factor Analysis and Therapeutic Opinion

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Objectives. *To identify independent risk factors for visceral artery aneurysms.*
Methods. *Retrospective medical record review over 10 years.*
Results. *There were 26 men and 15 women, median age of 54 (range 22 to 85), and median follow-up was 20.6 months (range 0 to 94 months). There were 11 splenic, 17 hepatic, 8 gastroduodenal, 6 pancreatoduodenal, 5 superior mesenteric, and two inferior mesenteric artery aneurysms. Thirteen patients (13/41, 31.7%) were treated surgically without adjuvant endovascular intervention. Nineteen patients (19/41, 46.3%) were treated exclusively using endovascular procedures. Five patients (5/41, 12.2%) received second endovascular or surgical treatment as salvage procedure after the first procedure failed.*

Concomitant malignancy was positive predictors for in-hospital death. Renal failure, chronic lung disease, liver cirrhosis, previous abdominal surgery and concomitant malignancy were positive predictors of 2-year mortality. With the intention to treat in the whole cohort, less than 10% (2/21) of the endovascular treatments failed, compared to 18.5% (3/16) in the surgical group. Patients treated by surgery without aid of endovascular intervention, have lower 2-year mortality. In hospital-death rate was 9.8%, while overall mortality rate was 21.9%.
Conclusions. *The endovascular intervention provides compatible, even better early postoperative outcomes for visceral artery aneurysms to surgery. Concomitant malignancy was the major determinant of visceral artery aneurysms, both in-hospital death and survival.*

Keywords: Visceral artery; Aneurysm; Risk factor; Surgery; Endovascular.

Introduction

Visceral artery aneurysms are rare, with an incidence of just 0.01% to 0.2% in routine autopsies. The pathogenesis and natural course of this disease remain poorly understood, literature reviews on this subject is scarce.[1] Visceral artery aneurysms are clinically important and potentially lethal. In 1986, Stanley et al reported that 22% of all visceral artery aneurysms present as clinical emergencies, while 8.5% result in death.[2]

In contrast to splenic artery aneurysms, which are historically the most common form of visceral artery aneurysms, hepatic artery aneurysms were the most frequently reported visceral artery aneurysm between 1985–1995.[3,4] This increased incidence of hepatic artery aneurysms is related to growing use of percutaneous biliary procedures, liver transplantations and the trend towards non-operative management of blunt liver injury.[5,6]

Despite recent advances in therapeutic techniques and diagnostic tools, the management of visceral artery aneurysms remains clinically challenging. This study reviewed the outcomes of 41 patients with visceral artery aneurysms and identified independent clinical variables associated with poor prognosis.

Patients and Methods

Patients

Information was collected retrospectively on all patients diagnosed with visceral artery aneurysms that occurred between June 1995 and June 2005. Data on age, sex, medical co-morbidity, aneurysm location, intervention, surgical procedure and clinical outcome were recorded according to standard guideline. The sample comprised 41 patients diagnosed with 49 visceral artery aneurysms.

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Definite infective endocarditis diagnosis was made according to Duke modification of the von Reyn criteria.[7]

In-hospital mortality defined as death within 30 days following intervention or following visceral artery aneurysms were diagnosed. Aneurysm-related death included recurrent gastrointestinal bleeding, free rupture into peritoneal, local abscess around the aneurysm and other conditions that directly attributed to the visceral artery aneurysms. Hospital stay dated from definite diagnosis of the visceral artery aneurysms to discharge or to death.

Typically, surgery and endovascular interventions are generally considered for patients with aneurysm >2 cm in diameter, rapid growth in aneurysm size, and symptoms attributable to the aneurysms. The decision to perform surgical or endovascular intervention was based on anatomic suitability and patient comorbidities. Observation is only reserved for asymptomatic patients with visceral artery aneurysms <2 cm in diameter.

Surgical technique

Surgical management comprised wide excision of aneurysms, with or without en bloc resection of adjacent organs.[8] Vascular reconstructions were performed in those with stable hemodynamic condition. In cases involving hypovolemic shock and multiple co-morbid patients, the surgical intervention included ligation of the feeding artery and aneurysmectomy. Surgical management for endovascular access complications, such as uncontrolled puncture site bleeding and femoral artery pseudoaneurysm, was excluded from analysis.

Endovascular intervention

Endovascular intervention consisted of coil embolization and absorptable gelatin sponge cube (Gelform) embolization performed via a percutaneous transfemoral approach. Interventions were performed by interventional radiologists under local anesthesia. Endovascular stent grafts for visceral artery aneurysms were not available in our institution within the period of this study.

Statistical analysis

Continuous variables were compared using an unpaired 2-tail Student *t* test. Moreover, discrete variables were compared using a 2-tailed Fisher exact test. Clinical parameters associated with survival were tested through log-rank analysis. The relative importance of the clinical variables was further assessed with a Cox proportional hazard model analysis. The actuarial survival curve was performed with the Kaplan-Meier method. All statistical analysis was conducted using STATA statistics/Data Analysis 8.0 software (Stata Corporation, College Station, TX). The results are mostly presented as mean values $\pm$ SD. Statistical significance was defined as p value ≤ 0.05.

Results

Patients

Table 1 lists the detailed distribution of aneurysms, gender ratio, and visceral-artery aneurysms-related procedures. The sample included 26 men and 15 women with a median age of 54 (range, 22−85 years) on admission, and the median age of 54 (range 22 to 85), and median follow-up was 20.6 months (range 0 to 94 months). Seven patients had multiple aneurysms. There were 11 splenic, 17 hepatic, eight gastroduodenal, six pancreatoduodenal, five superior mesenteric, and two inferior mesenteric artery aneurysms.

Medical co-morbid condition included diabetes mellitus in four patients, chronic obstructive lung disease in four patients, history of stroke in six patients, infective endocarditis in five patients, liver cirrhosis in nine patients, hypertension in fifteen patients, chronic renal failure with hemodialysis in two patients and systemic lupus erythematosus in two patients. Twenty patients had previous abdominal surgery. Eleven patients had malignancy (five pancreatic cancer, one Klatskin tumor, one hepatic cell carcinoma, one gastric cancer, one cervical cancer, one cholangiocarcinoma and one leukemia).

Four in-hospital deaths occurred, three of them related to the visceral artery aneurysms. The first case had received pancreaticoduodenectomy (Whipple's operation) for pancreatic cancer one month previously, with presentation of jaundice, severe upper gastrointestinal bleeding, and hypovolemic shock. Emergent arterial angiography disclosed a common hepatic aneurysm, which ruptured into the gastrointestinal tract. Although hemostasis was temporarily achieved by transcatheter coil embolization, the patient eventually succumbed as a result of recurrent bleeding. The second patient was a recurrence of hepatocellular carcinoma after hepatectomy, with lung metastasis. The patient presented with gastrointestinal bleeding, and angiography revealed a proximal gastroduedenal arterial aneurysm. The transcatheter emoblization failed to achieve complete hemostasis, and the exploratory

Table 1. Demographics, etiology and aneurysm-related procedure

Demographics				Etiology				Intervention			
Aneurysm location	Patient no	%	M/F	A	I	E	P	Surg	Cath	Both	Obs
Splenic artery	9	22.0	5/4	8	0	0	1	6	0	0	3
Splenic artery, Proximal	3			3				2			1
Splenic artery, Distal	3			3				3			
Splenic artery, undefined	1						1				1
Multiple aneurysm	2*			2				1			1
Hepatic artery	14	34.1	9/5	2	10	1	1	2	10	1	1
Left hepatic artery	2				2				2		
Right hepatic artery	4				3		1		3	1	
Common hepatic artery, single	5				4	1		2	3		
Celiac artery	1			1							1
Bilateral hepatic artery	1**				1				1		
Common hepatic artery, multiple	1*			1					1		
GDA and PDA	11	26.8	9/2	2	5	1	3	2	8	1	0
GDA	6			2	3		1	1	4	1	
GDA, multiple	1*						1		1		
PDA	2				1		1	1	1		
PDA, multiple	2*				1	1			2		
SMA and IMA	7	17.1	3/4	1	3	3	0	3	1	3	0
Ileal artery, proximal	2				1	1		1		1	
mesentary artery, distal	3				1	2		2	1		
IMA trunk	1				1					1	
left colic artery	1			1						1	
sum	41		26/15					13	19	5	4

Abbreviation. IMA: inferior mesenteric artery; GDA: gastroduodenal artery; PDA: pancreaticoduodenal artery; SMA: superior mesenteric artery.
Etiology A: atherosclerotic; Etiology I: iatrogenic (recent abdominal surgery); Etiology E: infective endocarditis; Etiology P: pancreatitis and intraabdominal abscess.
Surg: surgical-alone group; Cath: trans-catheter based therapy; Both: received surgery and transcatheter treatment; Obs: observation.
* two aneurysms.
** three aneurysms.

laparotomy was performed as a salvage procedure. The patient survived this episode but died of recurrent bleeding and sepsis three months later. The third patient had leukaemia with gastrointestinal bleeding during chemotherapy. This patient received multiple abdominal operations, including hepatojejunostomy for choledochocyst three years previously and T-tube insertion 20 days before the gastrointestinal bleeding. Angiographic study demonstrated a pseudoaneurysm from the posterior branch of the right hepatic artery that ruptured into the biliary tract, and the aneurysm was subsequently by coil embolization. The patient died of sepsis two weeks later. The fourth patient was a case splenic artery aneurysm. She was bedridden and had multiple co-morbidities, which precluded further intervention after the diagnosis. The patient died of intra-abdominal abscess.

Five patients died during follow-up. One patient received transcatheteric coil embolization for multiple pancreatico-duodenal artery aneurysms. This patient was admitted again two months later for pancreatic abscess around the aneurysm, and finally died of sepsis. The in-hospital death rate was 9.8% for this study, while two mortality rate was 21.9%.

Clinical presentations

The clinical presentations of the visceral artery aneurysms are listed in Table 2. Five patients (5/41, 12%) were asymptomatic; four splenic artery and one common hepatic artery aneurysm. Eighty-eight percent of

Table 2. Symptoms of visceral artery aneurysm

Presenting symptoms	No of patients	%
Asymptomatic	5	12
Symptomatic	36	88
Gastrointestinal bleeding	21	51.2
Abdominal pain	17	41.4
Shock	11	26.8
Rupture into peritoneum	5	12.2
Fever	5	12.2
Hemobilia	3	7.3
Jaundice	2	4.9

the visceral artery aneurysms were symptomatic. Gastrointestinal bleeding and abdominal pain were the most common symptoms, occurring in 50 and 43 percent of patients respectively. Eleven patients presented with hypovolemic shock: five cases were rupture of the aneurysm into the peritoneum and six patients with rupture into gastrointestinal tract causing massive bleeding.

Among five patients with infective endocarditis as initial clinical presentation, blood cultures were positive for *Streptococcus* species in three patients. The responsible organisms in the remaining two patients were *Escherichia coli* and *S. aureus*.

Surgery-alone

Thirteen patients (13/41, 31.7%) were treated surgically without adjuvant endovascular intervention. The surgical procedures, aneurysm locations and associated condition, are summarized in Table 3. The surgical procedures for the splenic artery aneurysms included aneurysmectomy with splenectomy (5/9) and aneurysmectomy with autologous graft interposition (1/9). Among the patients who received splenectomy, two distal pancreatectomy and one gastrorraphy were performed concomitantly. Meanwhile, among the aneurysms involving the hepatic, gastroduodenal, and pancreaticoduodenal arteries, surgical intervention was the only procedure in four patients. Three superior mesenteric artery aneurysms were treated surgically. Two of these patients subsequently underwent cardiac valve surgery (mitral valve repair and mitral valve replacement).

Table 3. Surgical procedures in Surgery-alone group

Artery	no	Surgical procedures
Splenic artery	2	Aneurysmectomy with splenectomy
	2	splenectomy, distal pancreadectomy and aneurysmectomy
	1	Aneurysmectomy and venous graft interposition (spleen preserve)
	1	Aneurysmectomy with splenectomy, gastrorraphy (aneurysm rupture into stomach)
Hepatic artery	1	Aneurysmectomy and venous graft interposition
	1	Ligation of gastroduodenal and common hepatic artery
GDA and PDA	1	near total pancreadectomy and aneurysmectomy
	1	Suture-ligation of the aneurysm in which ruptured into pancreatic pseudocyst
SMA	1	Aneurysmectomy + omentum flap (Mitral valve repair later)
	1	Aneurysmectomy, no bowel resection (Aortic valve endocarditis)
	1	Aneurysmectomy, no bowel resection (Mitral valve vegitation)

GDA: gastroduodenal artery; PDA: pancreatoduodenal artery; SMA: superior mesentary artery.

Endovascular-alone

Nineteen patients (19/41, 46.3%) were treated exclusively using endovascular procedures, including trans-arterial coil embolization and gelatin sponge cube (Gelform) embolization for the feeding arteries.

Other therapeutic conditions

Five patients (5/41, 12.2%) received both endovascular and surgical treatment for visceral artery aneurysms. The indications, procedure detail and aneurysm locations are listed in Table 4. Two patients received surgical salvage following endovascular procedures, one for the incomplete endovascular hemostasis and the other for post-embolization ischemic colon. And three patients underwent endovascular intervention for incomplete surgical hemostasis. With the intention to treat in the whole cohort, less than 10% (2/21) of the endovascular treatments failed, compared to almost 18.5% (3/16) in the surgical group. Four patients (4/41, 9.8%) were treated conservatively.

Outcome according to therapeutic approaches

Clinical features and outcomes were compared between the surgery-alone group and the endovascular-alone group (Table 5). The two groups did not differ in terms of gender, medical conditions, serum albumin level, total bilirubin level, in-hospital death, and aneurysm-related death.

Patients in the surgery-alone group were less previous abdominal surgery ($p < 0.001$) and frequently presenting with abdominal pain ($p = 0.029$). There was a lower incidence of presentation with gastrointestinal bleeding ($p = 0.01$) and lower two-year mortality ($p = 0.025$) in surgery alone group. In general, patients with visceral artery aneurysms, who tolerated surgery without the aid of endovascular intervention, had better health condition and longer survival.

Risk factor analysis

In-hospital death occurred in four patients, and was related to visceral artery aneurysms in three cases. Aneurysm-related death occurred in four patients, of whom three died in hospital and one died of intra-abdominal abscess around the visceral artery

Table 4. Combined procedure in detail

	Sequence	aneurysm	surgery	cath	Why
1	cath then surgery	Proximal GDA	exploratory ligation, of CHA and GDA	coil embolization, coil × 5	incomplete embolization
2	cath then surgery	left colic artery	Hemicolectomy	coil embolization, coil × 3	Ischemic colon
3	surgery then cath	proximal ileal artery	exploratory laparotomy, severe bowel adhesion due to previous gastrectomy	coil embolization, coil 2 × 3 mm and 2 × 5 mm microcoil	incomplete surgical hemostasis
4	surgery then cath	inferior mesentary artery	exploratory laparotomy for peritoneal sign, severe bowel adhesion due to previous pelvic surgery	coil embolization, coil × 2	cath as salvage procedure for surgery
5	surgery then cath	right hepatic artery	exploratory laparotomy for peritoneal sign, severe bowel adhesion due to previous gastrectomy	coil embolization, two of 2 × 3 microcoil	cath as salvage procedure for surgery

CHA: common hepatic artery; GDA: gastro-duodenal artery.

aneurysm two months after discharge. Eleven patients required hospital stay exceeding 30 days to complete their therapeutic course. There were nine patients dead at 2 years follow-up. The 30-day, 90-day, 1-year and 2-year estimated mortality rates were 9.8%, 9.8%, 14.6% and 21.9%, respectively.

For all 41 patients, concomitant malignancy was positive predictors of in-hospital death ($p = 0.003$). Meanwhile, renal failure ($p < 0.01$), chronic lung disease ($p < 0.01$), liver cirrhosis ($p = 0.018$), previous abdominal surgery ($p = 0.017$) and concomitant malignancy ($p < 0.01$) were positive predictors of 2-year mortality. Surgical treatment of visceral artery aneurysms without aid of endovascular intervention was a negative predictor of 2-year mortality ($p = 0.023$) (Table 6).

Cox proportional Hazard model to test the potential risk factor for survival are showed in Table 7. Concomitant malignancy has the most significant impact (Hazard ration: 39.17, $P = 0.008$) on the survival, followed by chronic lung disease (Hazard ratio: 18.3, $P = 0.026$).

Table 5. Comparison of surgery-alone vs endovascular-alone groups

Variable	Surgery alone ($n = 13$)		Endovascular alone ($n = 19$)		P
	n	%	n	%	
Male gender	8	61.50	13	68.42	.699[a]
Age (year)	45.6 ± 19.1		56.4 ± 13.2		.069
Albumin (g/dl)	3.23 ± 0.80		2.83 ± 0.733		.156
Hemoglobin (g/dl)	11.26 ± 2.15		8.40 ± 1.59		<.001*
total bilirubin (mg/dl)	1.32 ± 1.16		3.71 ± 4.34		.064
Chronic lung disease	1	7.69	2	10.53	.999[a]
Diabetes mellitus	0	0.00	3	15.79	.253[a]
Systemic lupus erythematosus	1	7.69	1	5.26	.999[a]
Endocarditis	3	23.10	2	10.53	.374[a]
History of stroke	1	7.69	3	15.79	.629[a]
Hemodialysis	0	0.00	2	10.53	.502[a]
Hypertension	4	30.84	7	36.84	.999[a]
Liver cirrhosis	1	7.69	7	36.84	.101[a]
Maligancy	1	7.69	8	42.11	.050[a]
Previous abdominal surgery	0	0.00	16	84.21	<.001[a]*
Abdominal pain	9	69.23	5	26.32	.029[a]*
Upper gastrointestinal bleeding	3	23.08	14	73.68	.010[a]*
In-hospital death	0	0.00	2	10.53	.502[a]
Admission >30 days	5	38.46	4	21.05	.427[a]
Aneurysm-related death	0	0.00	2	10.53	.502[a]
Two-year Mortality	0	0.00	7	32.14	.025[a]*

*: $P < .05$.
[a] Fisher Exact Test.

Discussion

With the increasing adoption of computed tomography and angiography, many visceral artery aneurysms are being identified before complications, specifically in patients being evaluated for abdominal pain or gastrointestinal bleeding. Management of visceral artery aneurysms remains an extremely challenging clinical problem. Significant questions exist regarding to the optimal therapeutic choice (surgery vs endovascular procedure), and the predictors of clinical outcome.

Therapeutic Choice in Different Condition

Surgery is the conventional treatment of visceral artery aneurysms, and its efficiency and durability were well documented.[5,10–13] Angiographic embolization of visceral artery aneurysms was an emerging option and the results obtained via this technique have been constantly improving. However, there are few studies examining the long-term results of endovascular treatment. This study will demonstrates the influence on the therapeutic choice of aneurysms locations, presenting symptoms and history of abdominal surgery.

Table 6. Risk Factors for Aneurysm-related Death and 2 years Mortality

Variable	$n = 41$ n (%)	p Values[a] In-hospital Death ($n = 4$)	p Values[a] Aneurysm-related Death ($n = 4$)	p Values[b] Mortality at 2 years ($n = 9$)
Male	26 (63)	0.999	0.999	0.6825
Risk Factors				
Diabetes Mellitus	4 (10)	0.348	0.348	0.0853
Hypertension	15 (37)	1	0.615	0.1496
Cerebrovascular Disease	6 (15)	0.483	0.095	0.0895
Coronary Artery Disease	2 (5)	1	0.188	0.3929
Congestive Heart Failure	2 (5)	1	0.188	0.3929
Infective Endocarditis	5 (12)	1	0.418	0.9586
Smoker	7 (17)	0.542	0.542	0.1016
COPD	4 (10)	0.348	0.041[c]	0.0045[c]
Renal Failure with Dialysis	2 (5)	1	0.188	0.0009[c]
Autoimmune Disease	2 (5)	1	1	0.4328
Liver Cirrhosis	9 (22)	1	1	0.0182[c]
Concomitant Malignancy	11 (27)	0.003[c]	0.052	0.0028[c]
Past Abdominal Surgery	20 (49)	0.343	0.343	0.0165[c]
Type of Intervention				
Combined Procedures	5 (12)	0.418	0.148	0.8183
Surgery-alone	13 (32)	0.288	0.288	0.0232[c]
Endovascular alone	19 (46)	1	1	0.0744

COPD = Chronic obstructive pulmonary disease.
[a] By Fisher's exact test.
[b] By log-rank test.
[c] p Value <0.05.

Splenic artery aneurysms

Sixty-six percent of splenic artery aneurysms in the present series (6/9) were excised surgically, and none received endovascular coil embolization. For splenic artery aneurysms, surgery generally consists of splenectomy and the removal of the portion of the splenic artery containing the aneurysm (aneurysmectomy). Distal pancreatectomy is performed when the aneurysms are deeply embedded within the pancreatic tissue. Splenic preservation without vascular reconstruction carries a risk of splenic infarction or abscess formation.[14] If the spleen is to be preserved during aneurysmectomy, then vascular reconstruction is required. This could be accomplished using an autologous saphnenous vein. Laparoscopic ligation has also been described for splenic artery aneurysms with good results, but experience of this procedure is limited.[15–17] Endovascular treatment is an emerging therapy for splenic artery aneurysms. Notably, endovascular embolizations are prone to develop major complications with distal splenic artery aneurysms, and should be avoided in such cases.[18]

There is a general consensus that treatment of asymptomatic splenic artery aneurysms is appropriate in pregnant patients or in women likely to become pregnant.[19] Rupture of splenic artery aneurysms most often occurred during pregnancy and was associated with a high maternal and fetal mortality rate. The opposite three patients in this series (one man and two menopausal women) with splenic artery aneurysms were safely observed.

Hepatic, gastroduodenal and pancreatoduodenal artery aneurysms

In contrast to the splenic artery aneurysms, the aneurysms located in the hepatic, gastroduodenal and

Table 7. Cox proportional Hazard model for potential risk factors affecting actural survival

Variance	Hazard Ratio	Standard Error	z	$P > \|z\|$	95% Confidence Interval	
Diabetes mellitus	3.570796	6.442629	0.71	NS	0.1039872	122.6169
Hypertension	0.9682991	0.9034042	−0.03	NS	0.1555446	6.027872
Chronic lung disease	18.38065	24.03521	2.23	0.026	1.416767	238.4642
Hemodialysis	12.82021	23.85307	1.37	NS	0.3343205	491.6172
Liver cirrhosis	5.885139	6.041003	1.73	0.084	0.7870671	44.00497
Previous abdominal surgery	1.251891	2.109807	0.13	NS	0.0460299	34.04809
Concominant Malignancy	39.17421	53.84024	2.67	0.008	2.64927	579.2611

NS: non significant, $P > 0.05$.

pancreatoduodenal arteries are mainly treated with endovascular intervention in this series. Only four patients with hepatic, gastroduodenal and pancreatoduodenal artery (4/25, 16%) were treated surgically without adjuvant endovasucular procedures. The main presenting signs of these visceral artery aneurysms are primarily intractable gastrointestinal bleeding, and definite diagnoses were obtained by via angiography arranged following a negative panendoscopic examination for peptic ulcer. Aneurysms of the proximal hepatic artery were treated via excision or exclusion without vascular reconstruction. Collateral circulation is usually sufficient through the superior mesenteric artery to the gastroduodenal artery. Revascularization should be performed in the distal lesion of hepatic arteries and those lesions involving the gastroduodenal artery. For intra-hepatic aneurysms, surgical correction may require hepatic resection of the area involved or ligation of the responding hepatic artery before it enters the liver parenchyma. In cases of pancreatoduodenal and gastroduodenal artery aneurysms, simple ligation is often difficult because of the existence of multiple communicating vessels. Endovascular coil embolization during angiographic study takes advantage in easily identifying and obliterating all the feeding arteries to the aneurysm in cases with such anatomic restrictions.[9]

Superior mesenteric, inferior mesenteric and celiac artery aneurysms

Superior mesenteric artery aneurysms account for 12% (5/41) of all visceral artery aneurysms in the present series, and mostly present as abdominal pain. Treatment of superior mesenteric artery aneurysms is mainly surgical, involving resection of the aneurysm and replacement with a graft in situations where the supply of blood to the bowel is compromised.[8] One superior artery aneurysm requires further endovascular embolization following a failed surgical exploration to achieve hemostasis. This patient was complicated by severe bowel adhesion owing to previous gastrectomy, which precluded complete surgical hemostasis. Adjuvant transcathertic coli embolization was undertaken to obliterate the feeding artery to the aneurysm and stop the bleeding. Notably, there was a very high percentage of concurrent infective endocarditis among patients with superior mesenteric artery aneurysms. Three of the superior mesenteric artery aneurysms (60%) have concurrent infective endocarditis, and two received subsequent cardiac valve surgery (mitral valve repair and mitral valve replacement, respectively). Visceral artery aneurysms in the superior artery aneurysms warrant further survey of possible infective endocarditis.[8,9,20]

Inferior mesenteric artery aneurysms can be treated endovascularly, but caution is necessary to avoid compromising the colon perfusion. One patient with inferior mesenteric artery aneurysm received endovascular coil embolization for inferior artery aneurysm developed ischemic colon two days following the procedure.

Influence of previous abdominal surgery and presenting symptoms

Previous abdominal surgery and presenting symptoms also impact therapeutic choice. Surgical intervention is more difficult in cases involving bowel adhesion and anatomic variation following previous abdominal surgery. Endovascular intervention thus became the preferred treatment option for aneurysms disclosed in the angiography for indeterminate gastrointestinal bleeding, especially in case of previous abdominal surgery.[21]

Chiesa reported the surgical experience in 31 visceral artery aneurysms and concluded that an aggressive surgical approach is justified by low morbidity and mortality rates associated with surgery.[13] Nonetheless, the cases in Chiesa's series were mainly splenic artery aneurysms in atherosclortic origin, rather than iatrogenic origin (i.e. aneurysm following abdominal surgery). Visceral artery aneurysms treated by surgery exclusively in our experience, also displayed excellent result. As shown in the Fig. 1, the survival curves of surgery alone and non-surgery alone groups, differ significantly.

Although endovascular intervention is inferior in terms of overall mortality, it achieves comparable efficiency to surgery in reducing aneurysm-related death and palliation of aneurysm-related symptoms, particularly in cases where surgery has been considered of high risk. Notably, 42% of subjects in the endovascular alone group exhibited history of malignancy and 84% of abdominal surgery. Currently, with the growing use of computed tomography and angiography, numerous aneurysms are being discovered in patients with poor clinical status. Such patients, who previously may have been excluded from surgery, received aggressive treatment via a less invasive endovascular procedures.

Predictors of Outcome

Most previous studies of visceral artery aneurysms described only few patients. Owing to the small

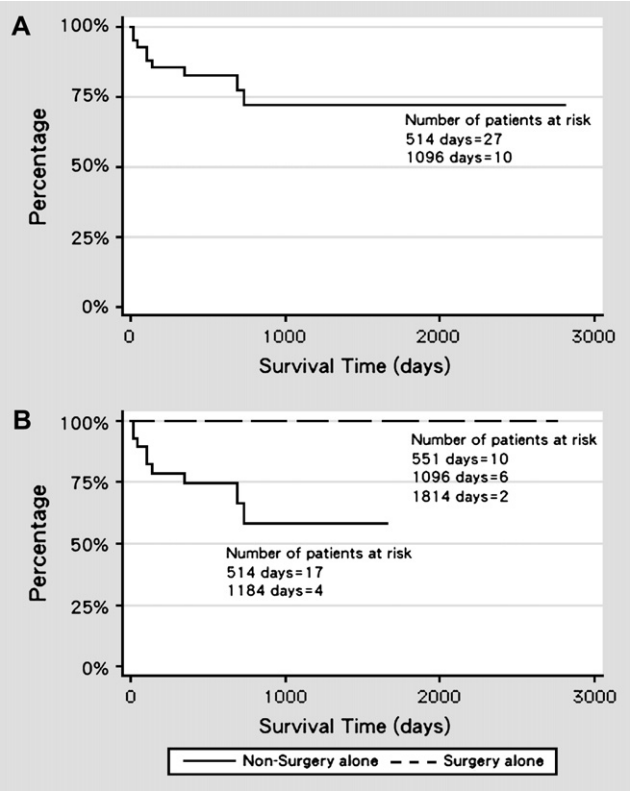

Fig. 1. A: Survival curve by Kaplan-Meier method in patients with visceral artery aneurysms. B: survival curves according to different therapeutic method (surgery alone vs. non-surgery alone).

number of subjects, it is impossible to demonstrate the statistically significant risk factors for the clinical outcome. In the present study, concomitant malignancy was positive predictors of in-hospital death ($p = 0.003$). Chronic obstructive pulmonary disease was a positive predictor of aneurysm-related death ($p = 0.041$). Renal failure ($p < 0.01$), chronic lung disease ($p < 0.01$), liver cirrhosis ($p = 0.018$), previous abdominal surgery ($p = 0.017$) and concomitant malignancy ($p < 0.01$) were all positive predictors of 2-year mortality. Surgical treatment of visceral artery aneurysms without aid of endovascular intervention was a negative predictor of 2-year mortality ($p = 0.023$). Aneurysm locations and different therapeutic choices were not predictors of in-hospital and aneurysm-related death.

Study Limitations

A retrospective characteristic of heterogeneity of the cohort is the major limitation of this investigation. With such limitations, we attempted to identify variables associated with poor prognosis and the influence of the treatment. However, this is the first study to analyze risk factors for death in patients with visceral artery aneurysms. Concomitant malignancy is the variable most strongly associated with aneurysm-related death as well as mortality. Further multi-institutional studies may provide further information regarding optimal therapeutic protocols and prognostic factors.

Conclusion

This study improves upon previous research by detailing the role of different therapeutic options and analyzed prognostic factors in visceral artery aneurysm. Concomitant malignancy is the major determinant of in-hospital mortality.

Successful treatment of visceral artery aneurysms requires high clinical suspicion, early diagnosis and timely intervention. Compared to surgery, the endovascular intervention provides compatible early postoperative outcomes for visceral artery aneurysms. Patients with visceral artery aneurysms, who tolerated surgery without the aid of endovascular intervention, had better health condition and longer survival.

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