ORIGINAL ARTICLES

From the Western Vascular Society

Contemporary management of isolated iliac aneurysms

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Objective: **Because isolated common iliac artery aneurysms are infrequent, are difficult to detect and treat, and have traditionally been associated with high operative mortality rates in reported series, we analyzed the outcomes of operative repair of 31 isolated common iliac artery aneurysms in 21 patients to ascertain morbidity and mortality rates with contemporary techniques of repair.**

Methods: **A retrospective review study was conducted in a university teaching hospital and a Department of Veterans Affairs Medical Center. Perioperative mortality and operative morbidity rates were examined in 17 men and four women with isolated common iliac artery aneurysms between 1984 and 1997. Ages ranged from 38 to 87 years (mean 69 ± 8 years). Slightly more than half of the cases were symptomatic, with abdominal pain, neurologic, claudicative, genitourinary, or hemodynamic symptoms. One aneurysm had ruptured and one was infected. There was one iliac artery–iliac vein fistula. All aneurysms involved the common iliac artery. Coexistent unilateral or bilateral external iliac aneurysms were present in four patients; there were three accompanying internal iliac aneurysms. Overall, 52% of patients had unilateral aneurysms and 48% had bilateral aneurysms. Aneurysms ranged in maximal diameter from 2.5 to 12 cm (mean 5.6 ± 2 cm). No patients were unavailable for follow-up, which averaged 5.5 years.**

Results: **Nineteen patients underwent direct operative repair of isolated iliac aneurysms. One patient had placement of an endoluminal covered stent graft; another patient at high risk had percutaneous placement of coils within the aneurysm to occlude it in conjunction with a femorofemoral bypass graft. Patients with bilateral aneurysms underwent aortoiliac or aortofemoral interposition grafts, whereas unilateral aneurysms were managed with local interposition grafts. There were no deaths in the perioperative period. Only one elective operation (5%) resulted in a significant complication, compartment syndrome requiring fasciotomy. The patient treated with the covered stent required femorofemoral bypass when the stent occluded 1 week after the operation. The patient treated with coil occlusion of a large common iliac aneurysm died 2 years later when the aneurysm ruptured.**

Conclusions: **Isolated iliac artery aneurysms can be managed with much lower mortality and morbidity rates than aneurysm previously been reported by using a systematic operative approach. Percutaneous techniques may be less durable and effective than direct surgical repair. (J Vasc Surg 1998;28:1-13.)**

An *isolated (or solitary) iliac artery aneurysm* is defined as a twofold increase in size of the iliac artery without a coexisting aneurysm at another location. Like aortic aneurysms, isolated iliac artery aneurysms typically occur in older men and are most commonly degenerative or nonspecific in etiology. Atherosclerosis may be simply synchronous rather than causal. Rarely, microorganisms can produce "mycotic" (infected) isolated iliac artery aneurysms. Historically, syphilis and tuberculosis were the causes of arterial infection, but *Salmonella, Staphylococcus aureus,* and *Klebsiella* species predominate in modern reports. Even less

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Presented at the Twelfth Annual Meeting of the Western Vascular Society, Lana'i, Hawaii, Sept. 27–Oct. 1, 1997.

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0741-5214/98 $5.00 + 0 **24/6/88277**

Table I. Bilaterality and location of isolated iliac aneurysms

			Location				
	n	%	*Artery*	*Right*	*Left*	*n*	%
Total common iliac artery aneurysms	31	100	Common iliac artery	13	18	31	100
Patients with bilateral aneurysms	10	48	External iliac artery	2	2	4	13
Patients with unilateral aneurysms	11	52	Internal iliac artery	3	0	3	10

Table II. Patient characteristics

Variable	*Result*
Demographics	
Total patients	21
Men	17 (81%)
Women	4 (19%)
Age range (yr)	38-87
Mean age (yr)	69 ± 8
Cigarette smoking (%)	71
Hypertension (%)	67
Coronary artery disease (%)	52
Previous coronary artery bypass grafting (%)	19
Hyperlipidemia (%)	9
Diabetes mellitus (%)	5
Symptoms	
Asymptomatic (%)	43
Abdominal pain (%)	19
Neurologic (%)	9.5
Claudication (%)	9.5
Genitourinary (%)	9.5
Hemodynamic (%)	9.5

commonly, iliac artery aneurysms are congenital or result from Marfan syndrome, Kawasaki syndrome, Ehlers-Danlos syndrome, Takayasu's arteritis, cystic medial necrosis, or spontaneous dissection. The incidence of solitary iliac aneurysms is difficult to determine precisely, but it is clear that isolated iliac aneurysms are rare, in contrast to abdominal aortic aneurysms. The clinical presentation of solitary iliac aneurysms is quite variable and often obscure. In recent times, many asymptomatic iliac artery aneurysms have been discovered incidentally as a result of the widespread use of abdominal ultrasonography and computed tomography (CT). Despite their rarity, isolated iliac artery aneurysms are more frequently symptomatic than are abdominal aortic aneurysms, and they carry a high rupture risk and associated high mortality rate. The mortality rate for elective repair of these aneurysms in older series has been reported to be as high as 50%,[1] and that in elective repair of iliac aneurysms was as high as 13% in one report only 6 years ago.[2] This report deals with 31 isolated iliac artery aneurysms in 21 patients who were treated on our vascular surgery service between 1984 and 1997. We describe the varied clinical presentations, operative strategies, and outcomes of these patients. The aim of this study is to determine morbidity and mortality rates associated with isolated iliac aneurysm management treated with contemporary techniques of repair in a systematic operative approach.

PATIENTS AND METHODS

Between August 1984 and August 1997, 21 patients with isolated common iliac artery aneurysms were treated at the University of Colorado Health Sciences Center and the Denver Department of Veterans Affairs Medical Center by one of four staff surgeons. A maximal diameter of at least 2.5 cm, as measured by CT scan, was required to establish the diagnosis of iliac artery aneurysm; patients with coexistent abdominal aortic or thoracic aneurysms (defined as arterial diameter >3 cm) were excluded from this study. Each patient's medical record was reviewed to determine the following variables: age, sex, clinical symptoms and signs, size and location of aneurysms, smoking status, presence of hypertension, history of coronary artery disease, previous coronary artery bypass grafting, presence of hyperlipidemia, and presence of diabetes. Methods of diagnosis and treatment were recorded. Main outcome measures were perioperative mortality and operative morbidity rates.

Operative strategy was tailored to the patient's general health status and specific arterial aneurysmal anatomy. In general, patients with bilateral aneurysms underwent aortoiliac or aortofemoral interposition grafts (or some combination thereof), whereas unilateral aneurysms were managed with local interposition grafts. Grafts were confined to the abdomen whenever possible, to avoid complications related to groin incision. If there was extensive external iliac involvement, however, a femoral anastomosis was constructed. In no instance was the aneurysm truly "resected," to avoid potential injury to nearby veins or ureters, although a portion of the aneurysmal wall was frequently resected to reduce the mass effect. Ureterolysis was not performed in any case.

RESULTS

Seventeen men and four women had 31 isolated common iliac artery aneurysms. Coexistent unilateral or bilateral external iliac aneurysms were present in four patients; there were three accompanying internal iliac artery aneurysms. Overall, 52% of patients had unilateral aneurysms and 48% had bilateral isolated iliac artery aneurysms (Table I). There were no coexistent femoral aneurysms, although generalized arterial ectasia was common. The mean age of the 21 patients was 69 ± 8 years (range 38 to 87 years). Table II summarizes the demographic features of the study patients. Slightly more than half (57%) of the patients had symptoms; 43% were symptom free and had their aneurysms discovered incidentally by physical examination or imaging studies. Abdominal pain was reported by four patients (19%). Two patients each (9.5%) reported neurologic symptoms, calf claudication, and urinary tract infection. The one patient whose aneurysm ruptured was first seen with abdominal pain and shock. Another patient was in hemodynamically unstable condition as a result of high-output congestive heart failure from a spontaneous isolated common iliac artery aneurysm–common iliac vein fistula.

All aneurysms were degenerative in origin, except for one infected by *Escherichia coli*. Except for the one patient who was first seen with a ruptured aneurysm, all patients underwent preoperative CT scans for determination of aneurysm size, architecture, and additional anatomic information; seven (23%) also underwent ultrasonographic examination, but these studies were less accurate and useful than CT scans. The one aneurysm that had ruptured was measured during the operation. Six aneurysms were palpable on abdominal or rectal examination. Preoperative angiograms were obtained for all electively treated patients and reviewed for coexistent occlusive disease, adequacy of pelvic circulation, and presence of aneurysms in all other arteries. Angiograms were considered essential for planning operative strategy. Isolated iliac aneurysms ranged in maximal diameter from 2.5 to 12 cm (mean 5.6 ± 2 cm).

Table III gives specific information about each patient's presenting symptoms if any and about aneurysm location, size, treatment, and outcome. Nineteen patients underwent direct operative repair of isolated iliac aneurysms. All nineteen operations were performed with general endotracheal anesthesia. One patient at high risk had placement of an endoluminal covered stent graft; another patient had percutaneous placement of coils within the aneurysm to occlude it in conjunction with a femorofemoral bypass graft placed with local anesthesia. A retroperitoneal approach was employed in seven patients with unilateral isolated iliac artery aneurysms (Fig. 1). All patients with bilateral aneurysms had standard transperitoneal midline incisions (Fig. 2). Wide exposure of the iliac arteries was performed with either transperitoneal or retroperitoneal approaches; use of the Omni-Tract (Omni-Tract Surgical, Minneapolis, Minn.) automatic retractor with special deep blades facilitated exposure. Great care was taken to avoid injury to adjacent iliac veins by good exposure, headlamp illumination, sharp rather than blunt dissection of the artery under direct vision, and careful placement of clamps to prevent "past-pointing." In part, avoidance of venous injuries explains the good results in this series.

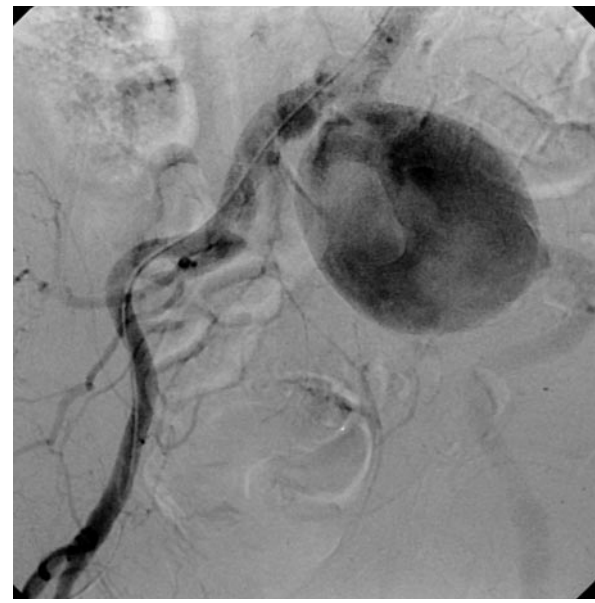

Fig. 1. Digital-subtraction arteriogram of an 82-year-old man with a unilateral 9.5 cm left common iliac aneurysm. Note redundant external iliac artery arising from the aneurysm. This patient was treated by retroperitoneal placement of an interposition graft from the proximal iliac artery to the external iliac artery, with exclusion of the internal iliac artery.

Hydronephrosis spontaneously resolved after simple repair of the iliac aneurysm in both patients who had this disorder. Of the three patients with coexistent internal iliac artery aneurysms, internal iliac artery revascularization with a "jump" graft was required in only one because the contralateral internal iliac artery was occluded. Each internal iliac artery aneurysm was managed by exclusion, with

Table III. Presentations of 21 patients with isolated iliac aneurysms

Age (yr)	*Sex*	*Symptoms and signs*	*Location*	*Maximum diameter (cm)*	*Treatment*	*Outcome*
78	F	Asymptomatic	RCIA	4.5	Graft interposition	Excellent
63	F	Fever, sepsis, LLQ pain	LCIA	3.0	Exclusion, femoro-femoral bypass	*C. difficile* colitis (colectomy); toe amputations
71	M	Urinary infection	RCIA, LCIA	4.2, 5.1	Aortobiiliac graft	Excellent
75	M	Heart failure	RCIA	4.3	Oversewing of arteriovenous fistula, graft interposition	Excellent
74	M	Asymptomatic	LCIA	5.3	Coil occlusion of CIA; femorofemoral bypass	Late death from ruptured LCIA
75	F	Asymptomatic	RCIA, LCIA	5.4, 3.0	Aortobiiliac graft	Excellent
58	M	Asymptomatic	LCIA	3.0	Graft interposition	Excellent
76	F	LLQ pain, hypotension	LCIA	4.5	Repair of ruptured LCIA, left aorto-femoral graft	Multiple organ failure, recovery
38	M	Sciatica (EDS)	LCIA	3.5	Graft interposition	Excellent
46	M	Asymptomatic	RCIA	4.0	Graft interposition	Excellent
70	M	Claudication	RCIA, LCIA	3.8, 5.0	Aorta–right iliac, aorta–left femoral bypass	Excellent
69	M	Asymptomatic	RCIA, REIA, LCIA	5.5, 3.2, 3.2	Aorta–right femoral; aorta–left iliac bypass	Excellent
73	M	Urinary infection	RCIA, RIIA, LCIA	3.5, 3.1, 3.3	Aortobiiliac graft	Excellent (late death from colon cancer)
66	M	Asymptomatic	RCIA, RIIA, LCIA, LEIA	5.0, 3.1, 3.6, 3.0	Aortobiiliac graft	Excellent
65	M	Claudication	LCIA, LEIA	12.0, 3.6	Stent-graft	Graft thrombosis; femorofemoral bypass
73	M	Femoral Neuropathy	RCIA, RIIA, LCIA	4.5, 4.0, 5.2	Aorta–right femoral; aorta–left iliac bypass	Excellent
87	M	Back/LLQ pain	LCIA	5.0	Graft interposition	Excellent
82	M	Asymptomatic	LCIA	9.5	Graft interposition	Excellent
68	M	Abdominal pain	RCIA, LCIA	4.0, 3.5	Aortobiiliac graft	Excellent
57	M	Asymptomatic	RCIA, LCIA	5.5, 4.5	Aortobiiliac graft	Excellent
49	M	Abdominal pain	RCIA, REIA, LCIA	7.0, 3.5, 4.2	Aorta–right femoral; aorta–left iliac bypass	Right leg compartment syndrome (fasciotomy)

RCIA, Right common iliac artery; *LLQ,* left lower quadrant; *CIA,* common iliac artery; *EDS,* Ehlers-Danlos syndrome; *LCIA,* left common iliac artery; *REIA,* right external iliac artery; *RIIA,* right internal iliac artery; *LEIA,* left external iliac artery.

oversewing of its major orifice (or several orifices when early branching occurred) from within the aneurysm. The patient with a spontaneous iliac artery–iliac vein fistula was treated with oversewing of the communication into the vein from within the arterial aneurysm, which in turn was then repaired with an aortoiliac graft interposition (Fig. 3). No attempt was made to obtain proximal or distal iliac venous control; instead, after proximal and distal arterial control, the aneurysm was opened and venous bleeding through the fistula was quickly limited by digital pressure.

There were no deaths in the perioperative period. Only one elective operation (5%), in a patient with a 7.0 cm common iliac artery aneurysm and a 3.5 cm external iliac artery aneurysm resulted in a significant complication, compartment syndrome requiring fasciotomy. In this patient the operative revascularization was complicated by embolization of intraluminal debris, which required embolectomy with prolonged lower extremity ischemia. The fasciotomy incisions were closed by skin grafting, and the patient recovered completely normal function. The two patients who underwent emergency operation also had postoperative complications. The patient with an infected aneurysm (Fig. 4) was treated with a prolonged course of broad-spectrum antibiotics and *Clostridium difficile* colitis developed, necessitating a left hemicolectomy with a colostomy. In addition, during her septic course, she

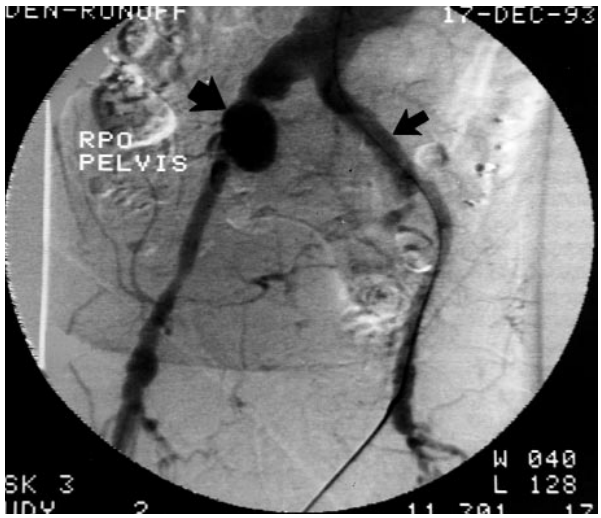

Fig. 2. CT scan of a 71-year-old man with bilateral common iliac artery aneurysms, measuring 4.2 and 5.1 cm, who was first seen with recurrent urinary tract infections. This patient was treated by transperitoneal placement of an aortobiiliac graft.

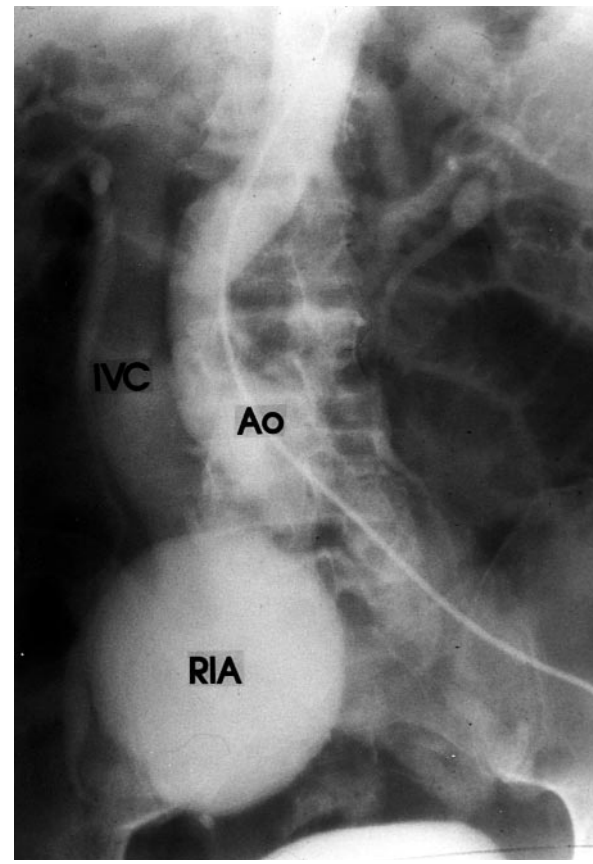

Fig. 3. Arteriogram of 75-year-old man who was first seen with right lower extremity edema and acute high-output heart failure. Note early filling of inferior vena cava after arterial contrast injection. *Ao,* Aorta; *RIA,* right common iliac artery; *IVC,* inferior vena cava.

had been placed on a regimen of intravenous norepinephrine, and gangrene developed in several toes that later required amputation. Eventually, she recovered completely. Finally, postoperative multiple organ failure developed in the woman who was first seen in shock from a ruptured isolated iliac aneurysm, and she required a long period of support in the intensive care unit. Eventually she too recovered completely.

Two patients with serious comorbid conditions were not treated by direct operative reconstruction. The patient treated with the covered stent required femorofemoral bypass when the stent occluded 1 week after the operation. The specific cause of the stent graft occlusion was not determined. The patient treated with coil occlusion of a large common iliac aneurysm died 2 years later when the aneurysm ruptured (Fig. 5). This patient had severe obstructive pulmonary disease, with a forced expiratory volume of 500 ml, and he refused surgery even when the rupture was diagnosed by CT scan before his death.

In contrast to the two patients treated by percutaneous techniques, the patients treated by direct operative approaches fared well. No patients were unavailable for follow-up, which avenged 5.5 years (range 2 months to 13 years). Primary graft patency was 100%. No patient has had a graft-related complication to date. Patients with unilateral iliac artery aneurysms have been followed up with annual abdominal CT scans; to date, no aortic or contralateral iliac aneurysms have developed.

DISCUSSION

In 1817 Sir Astley Paston Cooper performed the first operation for an iliac artery aneurysm in a 37-year-old man with a traumatic aneurysm of the external iliac artery that was eroding through the skin.[3,4] Cooper ligated the aorta above the aneurysm. Although the patient survived the operation, he died 40 hours later. Valentine Molt performed the first successful operation for a common iliac artery in a 33-year-old farmer in 1827.[5] Mott ligated the proximal iliac artery rather than the aorta, and 18 days later he found that the aneurysm was nonpulsatile when he removed the ligature percutaneously. In 1912 Halsted[6] reported on 15 cases in which iliac

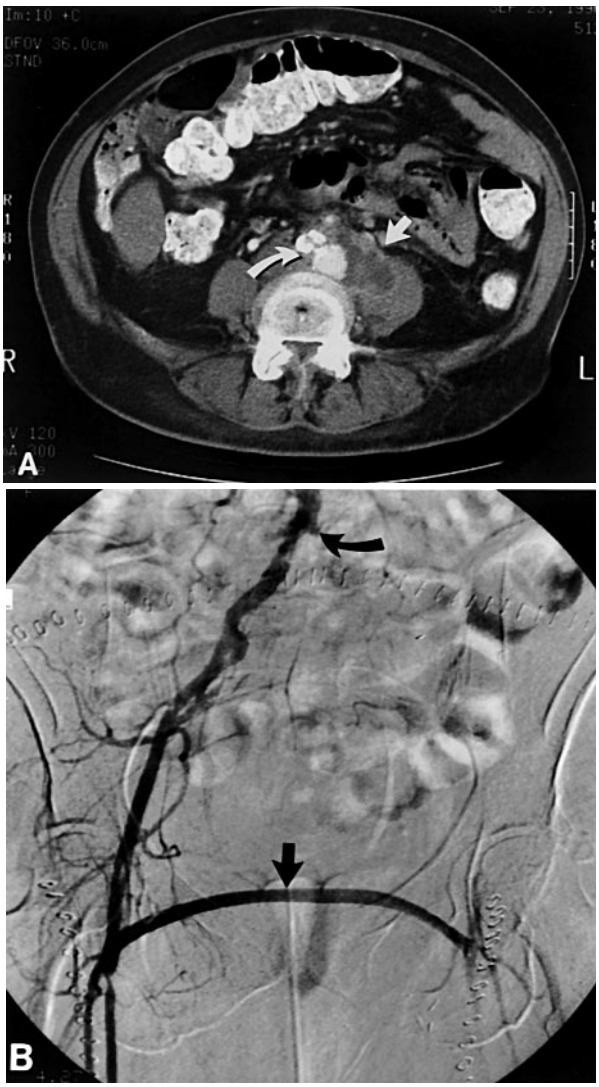

Fig. 4. Infected left iliac aneurysm in a 63-year-old woman. **A,** *Curved arrow* in CT scan shows the saccular common iliac aneurysm. *Straight arrow* points to attenuation in the psoas muscle as a result of purulent fluid, which was confirmed at operation. **B,** *Curved arrow* in arteriogram indicates ligated left common iliac artery at its origin. *Straight arrow* points to femorofemoral bypass graft.

artery ligation had been performed for aneurysm; only five patients survived the surgical procedure. MacLaren[7] successfully ligated a traumatic internal iliac aneurysm in a young woman after a difficult instrumental delivery in 1913. In 1923, more than a century after Cooper's innovative operation, Rudolph Matas[8] performed the first successful proximal aortic ligation of a combined aortoiliac aneurysm in a young man with syphilis, who later died of tuberculosis.

There is great variability in the estimated prevalences of isolated iliac aneurysms in both autopsy and clinical studies. In 12,000 necropsies, Lucke and Rea[9] found 268 subjects with 321 "intracorporeal" aneurysms. Of these 321 aneurysms, only one iliac (internal) aneurysm was discovered, for a frequency of 0.008%. However, Lucke and Rea's 1921 literature review[9] documented a reported incidence of aortoiliac aneurysms of only 0.9% in 160,145 autopsies, in contrast to more recent large investigations that suggest prevalences from 1.4% to 4%.[10,11]

More recently, in Malmo, Sweden (population 230,000), Brunkwall et al.[12] reported seven solitary iliac artery aneurysms in 26,251 hospital autopsies in a 15-year period, for an incidence of 0.03%. Six aneurysms had been asymptomatic and one had ruptured. In contrast, coexistent aortic and iliac artery aneurysms are common. Most often, iliac aneurysms arise from the distal extent of aortic aneurysms. In the autopsy series of Brunkwall et al.,[12] there were 202 iliac aneurysms among 1287 aortic aneurysms, for a prevalence of 16%. In general, iliac artery aneurysms coexist with abdominal aortic aneurysms in 10% to 20% of cases.

In one of the largest clinical series of isolated iliac artery aneurysms, Richardson and Greenfield[13] noted that iliac aneurysms comprised 2.2% of all intraabdominal aneurysms during a 13-year interval at the Medical College of Virginia. Nachbur et al.[14] reported a consecutive series of 678 aortoiliac aneurysms, of which 53 (7%) were isolated iliac aneurysms ranging in size from 3.5 to 14 cm. The highest incidence of isolated iliac artery aneurysms relative to abdominal aortic aneurysms was reported as 11.7% by Minato et al.[15] Prevalence of isolated iliac aneurysms may vary with geography. By means of discharge diagnostic codes, Lawrence et al.[16] estimated rates of iliac artery aneurysms of 3.6/1000 men in Utah, compared with 6.58/100,000 men in the United States as a whole; corresponding rates in women were 0.24/1000 and 0.26/100,000, respectively. Such discrepancies in reported frequencies may in part be explained by differences in definitions of iliac aneurysms and derivation of cases from autopsies, screening studies, or clinical series. Regardless of the precise incidence, it is clear that solitary iliac aneurysms are rare.

In our series of patients with common iliac artery aneurysms, one third had coexistent external or internal iliac artery aneurysms. Eighty percent of our patients had multiple aneurysms. These findings are consistent with previous reports in the literature, which indicate that about 70% of solitary

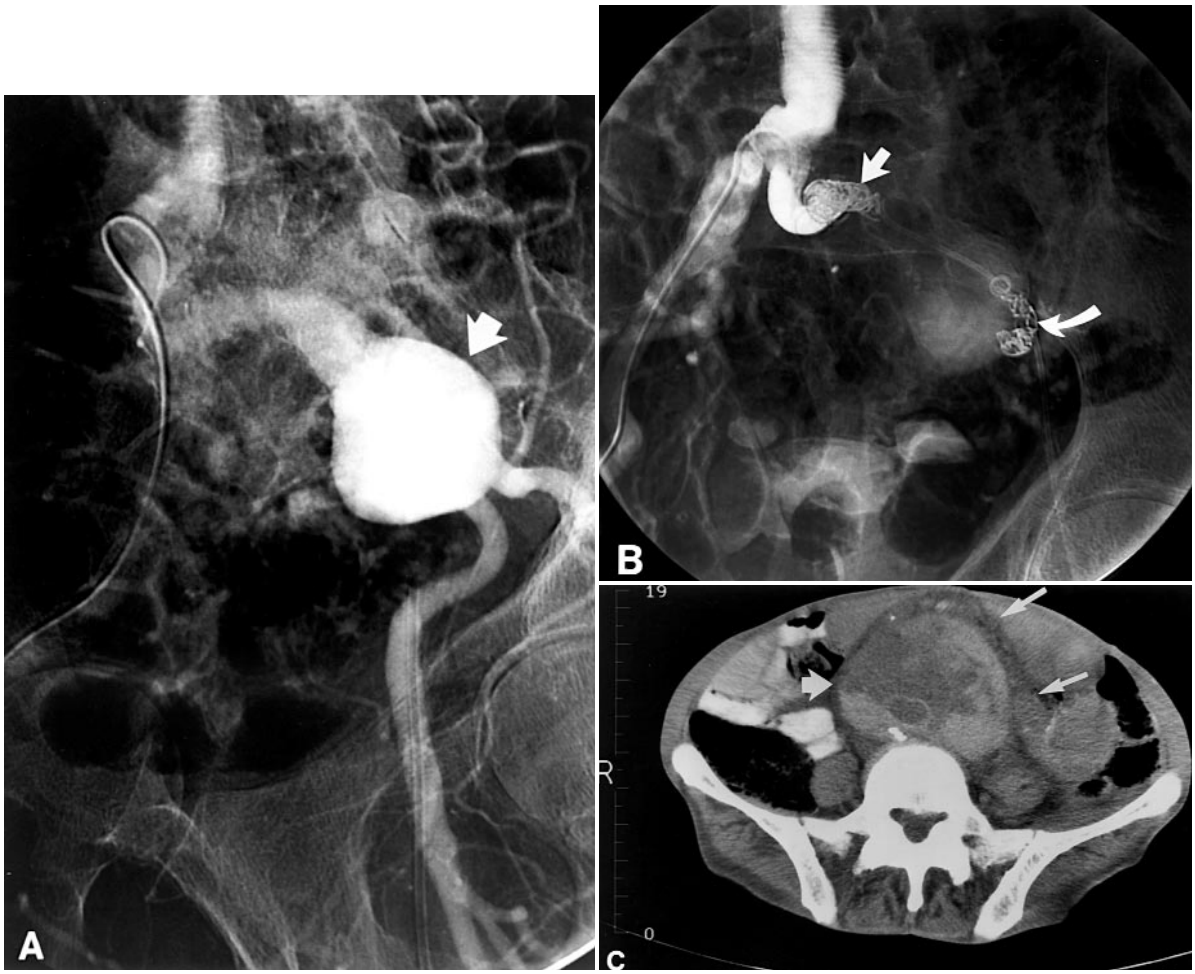

Fig. 5. Large left common iliac aneurysm in a 74-year-old man at high risk. **A,** *Arrow* in arteriogram shows aneurysm. **B,** *Straight arrow* shows coils occluding proximal common iliac artery; *curved arrow* points to coils in the orifice of the hypogastric artery. The external iliac artery was ligated during the femorofemoral bypass. **C,** CT scan of the same patient 2 years later showing large intraabdominal hematoma as a result of rupture of the common iliac artery aneurysm. *Arrows* indicate the edge of the hematoma, which extends from the iliac artery to the renal arteries.

iliac artery aneurysms occur in the common iliac artery, 20% occur in the internal iliac artery, and the remainder occur in the external iliac.[17] The reason for this distribution is unknown. The multiplicity of iliac aneurysms was underscored in the large series reported by Richardson and Greenfield,[13] in which 67% of patients were noted to have two or more vessels involved. Isolated iliac artery aneurysms occur with about equal frequency on the right and left sides.

Although the natural history of isolated iliac artery aneurysms is largely unknown, rupture occurs frequently. In contrast to our series, in which only one of 21 patients had a ruptured iliac aneurysm, most investigators have reported high incidences of rupture (Table IV).[2,18-27] For example, in the 55 patients (with 72 aneurysms) reported on by Richardson and Greenfield,[13] one third were initially seen with rupture. In general, perioperative death occurs in one third to one half of patents with ruptured aneurysms. Elective mortality rates have improved substantially from the 42% reported in the first large series in 1961.[18] Complication rates generally remain high, however, with complications occurring in about one third of patients in most reports.

Table III illustrates the wide range of symptoms in our patients. The clinical manifestations of iliac

Table IV. Isolated iliac aneurysms: Series of five or more patients

						Rupture		*Symptomatic*		*Asymptomatic*				
1st au.	*Ref*	*Year*	*Pts*	*IIAs*	*Mean age (yr)*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*Ops.*	*Emergency mortality (%)*	*Elective mortality (%)*
Markowitz	18	1961	30	30	65	5	17	14	47	16	53	12	80	42
Lowry	1	1978	8	8	68	6	75	4	50	4	50	8	67	0
Brin	19	1982	5	6	41	3	60	2	40	3	60	5	67	0
McCready	20	1983	50	71	70	7	14	12	24	38	76	24	57	0
Perdue	21	1983	6	6	67	2	33	5	83	1	17	4	25	0
Plate	22	1985	6	6	68	2	33	NS	NS	NS	NS	6	50	33
Richardson	13	1988	55	72	75	18	32	30	55	25	45	44	33	11
Bolin	23	1988	16	22	69	9	56	7	44	9	56	9	33	0
Weber	24	1989	23	23	72	19	82	23	100	0	0	22	22	NS
Weimann	25	1990	22	30	64	5	23	15	68	7	22	22	40	0
Schroeder	2	1991	30	55	71	0	0	NS	NS	NS	NS	30	NA	13
Nachbur	14	1991	53	53	68	15	28	51	96	2	4	53	20	0
Sacks	26	1992	11	18	75	3	27	11	100	0	0	10	0	0
Minato	15	1994	16	44	71	4	25	9	56	7	44	13	50	0
Desiron	27	1995	15	25	69	9	60	13	86	2	14	15	56	0
Current series	NA	1997	21	31	69	1	5	12	57	9	43	21	0	0
Total			367	500	68	108	29	208	62	123	38	298	40	7

au, Author; *Ref,* reference; *Pts,* patients; *IIAs,* isolated iliac arteries; *Ops,* operations; *NS,* not stated; *NA,* not applicable.

aneurysms depend on the etiology, size, location, and coexisting disorders (e.g., connective tissue disease, abuse of intravenous drugs). More than half of the patients with iliac aneurysms report symptoms related to their aneurysms (Table IV). Compression or erosion of surrounding structures and rupture are most frequent presenting symptoms. Sepsis from ureteral obstruction and subsequent pyelonephritis often occurs, and erosion or rupture into the ureter or bladder can cause microscopic or massive hematuria.[28] Compression of femoral, obturator, or sciatic nerves may produce neurologic symptoms.[28-30] An unusual but dramatic presentation, as seen in one of our patients (Fig. 3), is massive leg swelling and acute congestive heart failure produced by spontaneous rupture of an iliac artery aneurysm into the adjacent vein, resulting in a large arteriovenous fistula.[31,32] Our patient with an infected isolated iliac aneurysm (Fig. 4) is the second such case reported in the literature.[33]

Physical examination can suggest the diagnosis of iliac artery aneurysms if the physician has a high index of suspicion. Most symptomatic iliac aneurysms can be palpated as pulsatile masses on abdominal or rectal examination.[13, 28] Although iliac aneurysms are unusual in women, gynecologic examination may occasionally disclose them. Perianal ecchymosis caused by dissection of blood through the retroperitoneal space and decreased sphincter tone have been reported after rupture of iliac aneurysms.[1] Bruits, thrills, and shock are not specific for aneurysms involving the iliac arteries.

The diagnosis of isolated iliac aneurysms may be confirmed by ultrasonography, CT scans, magnetic resonance imaging, and arteriography. Although ultrasonography is much less expensive than the other modalities, it is operator dependent and often inaccurate because of the depth of the arteries in the pelvis or the presence of overlying intestinal gas. A study comparing ultrasonography, CT, and intravenous digital-subtraction arteriography for study of abdominal aneurysms found that ultrasonography did not detect iliac aneurysms in 19 of 25 cases.[34] Transanal ultrasonography may be of use for diagnosing internal iliac artery aneurysms. CT and magnetic resonance imaging are equally accurate for diagnosing iliac aneurysms, but magnetic resonance imaging is more expensive. Arteriography may miss iliac artery aneurysms because of thrombotic debris filling the aneurysmal sac. However, there is general agreement that arteriography to assess the pelvic circulation is essential for planning elective repair of iliac aneurysms.

There is no large prospective series describing the natural history of isolated iliac aneurysms. The limited number of cases reported, all of which are either anecdotal or retrospective analyses, makes any recommendation for treatment largely empirical. Rupture has been reported in aneurysms as small as 2 cm, but the measurements in these patients were

made in the presence of hypotension and may be inaccurate.[13] It is extremely unusual for an iliac aneurysm smaller than 3 cm to rupture. Similar to aortic aneurysms, iliac aneurysms tend to enlarge unpredictably. The Mayo Clinic group estimated an average expansion rate of 4 mm per year.[20]

As with aortic aneurysms, size seems to be the most important determinant for rupture of iliac aneurysms. The mean arterial diameter in the report of Lowry and Kraft,[1] in which 75% of patients had rupture, was 7.5 cm. Although they did not specifically correlate size with rupture, Schuler and Flanigan[35] reported that nine of 13 patients (69%) died of ruptured aneurysms about 4 months after the diagnosis; the mean size of the 69 iliac aneurysms in this series was 8.5 cm. Most authorities recommend that patients with isolated iliac artery aneurysms larger than 3 cm in diameter who otherwise are good operative risks should undergo elective repair.

Our results show that operative repair of isolated iliac artery aneurysms can be performed with minimal morbidity and mortality. Operative strategy depends on which arteries are involved and the presence or absence of multiple aneurysms, particularly when they are bilateral. Solitary common iliac artery aneurysms are best treated by retroperitoneal exposure and replacement with interposition prosthetic grafts (Fig. 1). If the contralateral internal iliac artery is undiseased, the ipsilateral internal iliac can be safely ligated. If the ipsilateral internal iliac artery is also aneurysmal, it is advisable to open the sac and ligate the branches of the artery from within the aneurysm, rather than risk injury to the many adherent veins surrounding the external surface of the aneurysm. After graft interposition is completed, the graft should be encircled by the aneurysm wall, as is usually done for abdominal aortic aneurysm repair.

Bilateral common iliac artery aneurysms are usually best managed by exclusion with a bifurcated prosthetic interposition graft originating from the abdominal aorta by means of a transperitoneal approach. At least one distal anastomosis should incorporate the lumen of the internal iliac artery. Alternatively, a "jump" graft can be taken to one of the internal iliac arteries. If both internal iliac arteries are aneurysmal and must be excluded from circulation, one should ensure that the inferior mesenteric artery is patent. It is often difficult to place a "jump" graft to the more normal distal internal iliac artery because the large size of most internal iliac artery aneurysms precludes exposure deep within the pelvis. Reimplantation of the inferior mesenteric artery into a prosthetic graft may be required when an aortic replacement is performed in such instances, although often the aortic graft may originate below the inferior mesenteric artery when the aorta is normal (in contrast to the preferred immediately infrarenal placement of grafts when the aorta is diseased). Impotence should be anticipated when both internal iliac arteries are removed from in-line flow.

Our two patients treated by percutaneous techniques did not fare well. Whereas long-term primary graft patency was 100% in patients who were operated on, the one patient treated with a covered stent had early graft occlusion requiring emergency femorofemoral bypass. Most disturbing is the late fatal aneurysmal rupture in the patient managed with coil embolic occlusion of an iliac artery aneurysm (Fig. 5). Although several authors have suggested this approach with embolization with Gelfoam (UpJohn-Pharmacia, Kalamazoo, Mich.), steel coils, thrombin, or cyanobucrylate by means of interventional radiologic techniques,[36,37] it should be remembered that such techniques usually failed to prevent ruptures when they were used for treatment of abdominal aortic aneurysms before the advent of prosthetic interposition grafting. Conducting an electric current between needles stuck into an aneurysm in an effort to thrombose it was first attempted in 1832; this technique was still popular in the 1930s. In 1864, at Middlesex Hospital in London, Charles Hewitt Moore (born 1821, died 1870) introduced obliteration of aneurysms by inserting steel wires, once using 26 yards of the material.[5] When abdominal aortic aneurysm thrombosis was resurrected in the modern era, rupture remained a problem.[38,39] In the Markowitz and Norman series,[18] in which 12 patients underwent operations for isolated iliac artery aneurysms, two were treated with wire occlusion; both died of ruptured aneurysms.

Currently there is great enthusiasm for endovascular repair of aortic and iliac aneurysms. Although some have advocated use of noncovered self-expanding stents for treatment of iliac artery aneurysms,[40] most centers are using endovascular grafts of several varieties. Initial results with percutaneous endoluminal stent-grafts were quite good in nine isolated iliac aneurysms in eight patients, but median follow-up was only 8.5 months.[41] Marin et al.[42] recently described transfemoral endovascular repair of 14 isolated iliac artery aneurysms in 11 patients by means of stent-grafts. Again, follow-up was relatively short (11 months), and three patients (27%) had complications (transient colonic ischemia, groin lymphocele, distal embolization with graft kink requiring a stent).

Moreover, length of stay was surprisingly long (range 2 to 12 days, mean 5 days). The largest experience for endovascular repair of iliac artery aneurysm is a recently reported multicenter French study.[43] Twenty-seven iliac artery aneurysms in 26 patients were repaired by transfemoral placement of stent-grafts. Morbidity and mortality were high. One patient (4%) died of bleeding from an arterial puncture site 2 days after the procedure, two patients had failure of device insertion and required operative intervention, and two patients had persistent flow within the iliac aneurysm. Thus the immediate failure rate was 19%. At a mean follow-up of 12 months, one graft had thrombosed, requiring surgical intervention, and restenosis requiring percutaneous angioplasty had developed in another. In all, the early and late adverse event rate was 27%. These are sobering statistics when compared with the outcomes in our operative series, suggesting that the indications for endovascular repair of isolated iliac aneurysms remain to be defined pending studies of long-term outcome.

Our experience indicates that isolated iliac artery aneurysms can be managed by operative repair safely and effectively with a systematic approach. On the basis of two patients in our series and a review of the few reports in the literature, we conjecture that percutaneous techniques may be less durable and less effective than direct surgical repair. Longer term follow-up is indicated to assess the efficacy and durability of endovascular grafts for treatment of iliac aneurysms.

REFERENCES

1. Lowry WF, Kraft RO. Isolated aneurysms of the iliac artery. Arch Surg 1978;113;1289-93.
2. Schroeder RA, Flanagan TL, Kron I, Tribble CG. A safe approach to the treatment of iliac artery aneurysms: aorto-bifemoral bypass grafting with exclusion of the aneurysm. Am Surg 1991;57:624-6.
3. Osler W. Remarks on arterio-venous aneurysm. Lancet 1915;2:949.
4. Cooper AP. Lectures on the principles and practice of surgery. 2nd ed. London: FC Westley; 1830. p. 153-76.
5. Haeger K. The illustrated history of surgery. New York: Bell Publishing; 1988.
6. Halsted WS. The effect of ligature of the common iliac artery on the circulation and function of the lower extremities. Trans Am Surg Assoc 1912;30:196-200.
7. MacLaren A. Aneurysm of the internal iliac artery, probably following a severe instrumental delivery: operation and partial cure. Ann Surg 1913;117:73-7.
8. Matas R. Ligation of the abdominal aorta. Ann Surg 1925;457:457-62.
9. Lucke B, Rea MH. Studies on aneurysm: general statistical data on aneurysm. JAMA 1921;77:935-40.
10. Lederle FA, Johnson GR, Wilson SE, Chute EP, Littooy FN, Bandyk D, et al. Prevalence and associations of abdominal aortic aneurysm detected through screening. Ann Intern Med 1977;126:441-9.
11. Bengtsson H, Bergqvist D, Sternby NH. Increasing prevalence of abdominal aortic aneurysms: a necropsy study. Eur J Surg 1992;158:19-23.
12. Brunkwall J, Hauksson H, Bengtsson H, Bergqvist, Takolander R, Bergentz SE. Solitary aneurysms of the iliac arterial system: an estimate of their frequency of occurrence. J Vasc Surg 1989;10:381-4.
13. Richardson JW, Greenfield LJ. Natural history and management of iliac aneurysms. J Vasc Surg 1988;8:165-71.
14. Nachbur BH, Inderbitzi RGC, Bar W. Isolated iliac aneurysms. Eur J Vasc Surg 1991;5:375-81.
15. Minato N, Itoh T, Natsuaki M, Nakayama Y, Yamamoto H. Isolated iliac artery aneurysm and its management. Cardiavasc Surg 1994;2:489-94.
16. Lawrence PG, Lorenzo-Rivero S, Lyon JL. The incidence of iliac, femoral, and popliteal artery aneurysms in hospitalized patients. J Vasc Surg 1995;22:409-16.
17. Krupski WC. Isolated iliac aneurysms. In: Ernst CB, Stanley JC, editors. Current therapy in vascular surgery. 3rd ed. St. Louis: Mosby; 1994. p. 296-302.
18. Markowitz AM, Norman JC. Aneurysms of the iliac artery. Ann Surg 1961;154:777-86.
19. Brin B, Busuttil RW. Isolated hypogastric artery aneurysms. Arch Surg 1982;117:1329-33.
20. McCready RA, Pairolero PC, Gilmore JC, Kazmier FJ, Cherry KJ, Hollier LH. Isolated iliac artery aneurysms. Surgery 1983;93:688-93.
21. Perdue GD, Mittenthal MJ, Smith RB 3rd, Salam AA. Aneurysms of the internal iliac artery. Surgery 1983;93:243-6.
22. Plate G, Hollier LA, O'Brien P, Pairolero PC, Cherry KJ, Kazmier FJ. Recurrent aneurysms and late complications following repair of abdominal aortic aneurysms. Arch Surg 1985;120:590-4.
23. Bolin T, Lund K, Skau T. Isolated aneurysms of the iliac artery: what are the chances of rupture? Eur J Vasc Surg 1988;2:213-5.
24. Weber E, von Segesser L, Turina M. Ruptur isolierter iliakalaneurysmen. Helv Chir Acta 1989;56:275-8.
25. Weimann S, Tauscher TH, Flora G. Isolated iliac artery aneurysms. Ann Vasc Surg 1990;4:297-301.
26. Sacks NPM, Huddy SPJ, Wegner T, Giddings AEB. Management of solitary iliac aneurysms. J Cardiovasc Surg 1992;33:679-82.
27. Desiron Q, Detry O, Sakalihasan N, Defraigne JO, Limet R. Isolated atherosclerotic aneurysms of the iliac arteries. Ann Vasc Surg 1995;9(suppl):S62-6.
28. Krupski WC, Bass A, Rosenberg GD, Dilley RB, Stoney RJ. The elusive isolated hypogastric artery aneurysm: novel presentations. J Vasc Surg 1989;10:557-62.
29. Skejo PB, Sloth H. An isolated aneurysm of the internal iliac artery simulating lumbar disc herniation. Acta Chir Scand 1989;155:65-6.
30. Martin M, Kwasnik EM, Wright SC. Combined femoral neuropathy and psoas sign: an unusual presentation of an iliac artery aneurysm. Am J Med 1990;88:435-6.
31. Weimann S, Flora G. Primary arteriovenous fistula between the common iliac vessels secondary to aneurysmal disease. Surgery 1987;102:91-5.
32. Brewster DC, Cambria RP, Moncure AC, Darling RC, LaMuraglia GM, Geller SC, et al. Aortocaval and iliac arteri-

ovenous fistulas: recognition and treatment. J Vasc Surg 1991;13:253-65.
33. Asplund MW, Molinaro A. Infected solitary iliac artery aneurysm. J Vasc Surg 1990;12:219-20.
34. Vowden P, Wilkinson D, Ausobsky JR, Kester RC. A comparison of three imaging techniques in the assessment of an abdominal aortic aneurysm. J Cardiovasc Surg 1989;30:891-6.
35. Schuler JJ, Flanigan DP. Iliac artery aneurysms. In: Bergan J, Yao JST, editors. Aneurysms: diagnosis and treatment. New York: Grune and Stratton; 1982. p. 469-85.
36. Rogoff PA, Stock JR. Percutaneous transabdominal embolization of an iliac artery aneurysm. AJR Am J Roentgenol 1985;36:1258-60.
37. Hollis HW, Luethke JM, Yakes WF, Beitler AL. Percutaneous embolization of an internal iliac artery aneurysm: technical considerations and literature review. J Vasc Interv Radiol 1994;5:449-51.
38. Cho SI, Johnson WC, Bush HL, Widrich HC, Huse JB, Nabseth DC. Lethal complications associated with nonresective treatment of abdominal aortic aneurysms. Arch Surg 1982;117:1214-7.
39. Kwaan JHM, Dahl RK. Fatal rupture after successful surgical thrombosis of an abdominal aortic aneurysm. Surgery 1984;95:235-7.
40. Vorwerk D, Gunther RW, Wendt JG, Schurmann K. Ulcerated plaques and focal aneurysms of iliac arteries: treatment with noncovered, self-expanding stents. AJR Am J Roentgenol 1994;162:1421-4.
41. Razavi MK, Dake MD, Semba CP, Nyman URO, Liddell RP. Percutaneous endoluminal placement of stent-grafts for the treatment of isolated iliac aneurysms. Radiology 1995;197:801-4.
42. Marin ML, Veith FJ, Lyon RT, Cyamon J, Sanchez LA. Transfemoral endovascular repair of iliac artery aneurysms. Am J Surg 1995;170:179-82.
43. Cardon JM, Cardon A, Joyeux A, Vidal V, Noblet D. Endovascular repair of iliac artery aneurysm with endoprosystem I: a multicentric French study. J Cardiovasc Surg 1996;37:45-50.

Submitted Sep. 25, 1997; accepted Dec. 17, 1997.

DISCUSSION

Dr. Robert J. Hye (San Diego, Calif.). The University of Colorado group has presented a 13-year experience comprised of 21 patients with a total of 31 aneurysms confined to the iliac arteries. They have highlighted the rarity of this condition, the difficulty in diagnosis, and the high reported mortality rates of 30% to 50% when rupture occurs.

Demographically, their series is similar to previous series of isolated iliac artery aneurysms and those of abdominal aortic aneurysms. The patients are predominantly men with a mean age of 69 years; 70% were cigarette smokers, and 52% had a history of coronary artery disease. Most had multiple aneurysms, and 57% were symptomatic. This series differs from previous series in that only one patient was first seen with rupture, yet the incidence rate in other series averaged 30%.

Operative repair was performed in 19 patients and was consistent of aortobifemoral or biiliac grafting for patients with bilateral aneurysms and interposition grafts for patients with unilateral aneurysms. Two high-risk patients were managed with endovascular techniques; one with a stent graft, and the other with coil embolization. Both outcomes of the latter approach were poor, with thrombosis of the stent graft at 1 week and rupture of the coil embolized aneurysm at 2 years.

The results of elective operative repair were excellent, with no operative mortality, only one major complication, and 100% primary graft patency rate at a mean follow-up of 5.5 years.

The primary conclusion of this paper is that current surgical approaches result in extremely low morbidity and mortality rates in repair of isolated iliac artery aneurysms. The authors point to the poor outcomes in their small experience with endovascular techniques and to reports in the literature from Drs. Marin and Cardon with early and late complication rates totaling 27%. They conclude that operative repair is the more durable and effective approach.

There is not much new information in this paper, but it adds to the body of literature that documents the effectiveness of operative repair of these aneurysms. Five reports since 1991, including this one, describe 84 patients repaired electively without mortality.

I have three questions and a comment for the authors. Prior series and your study report symptoms in an average of 62% of patients with isolated iliac aneurysms. When one examines the papers carefully, however, many of the symptoms cannot be attributed to the aneurysms. Do you believe that iliac aneurysms are more likely to be symptomatic, or does their occult nature just make them more likely to be discovered in the course of a workup for urologic, pelvic, or leg symptoms? Secondly, given the limitations of ultrasound scan in screening for iliac aneurysms, can you make any recommendations regarding a demographic profile that would justify screening for these aneurysms with computed tomography? Thirdly, on the basis of your experience and your familiarity with this literature, do you believe there is any difference in operative risk between patients with isolated iliac aneurysms and those with infrarenal abdominal aortic aneurysms?

Finally, as the paper indicates, Dr. Halsted's mortality rate in operative repair of iliac aneurysms in 15 patients reported in 1912 was 66%. It is undoubtedly too early to judge the effectiveness of endovascular repair for this condition, but series such as this provide a valuable benchmark for comparison.

Dr. William C. Krupski. Thanks you for your comments and questions. With respect to the first question, I think the iliac aneurysms are truly symptomatic. I base that on the fact that the pelvis is narrow and it is more like-

ly to cause compression of nearby structures. In addition, most of the patients who were symptomatic in our series were asymptomatic after their aneurysms were repaired.

For example, two patients were first seen with recurrent urinary tract infections and had no more urinary sepsis after iliac aneurysm repair. Two patients were first seen with neurologic symptoms; one with femoral neuropathy, and one with sciatica. These symptoms also disappeared after repair of the aneurysms. So, I think they are more likely to be symptomatic than abdominal aortic aneurysms where the territory is more "wide open."

Your second question regarded the demographic profile that might allow for a computed tomography screening of these patients. I think that it is highly unlikely that any profile can ever be developed because the aneurysms are so rare. It would never be cost effective to screen with computed tomography scanning. You are right that ultrasound scan is notoriously inaccurate for diagnosing iliac artery aneurysms because they are deep within the pelvis, there is often overlying gas, and so on. So, it is unlikely that ultrasound screening, although less expensive, will be worthwhile.

As you know, there was a series in the Journal of Cardiovascular Surgery published in 1989 that compared computed tomography and ultrasound scan for the diagnosis of iliac artery aneurysms. Ultrasound scan missed 19 of 25 aneurysms that had been diagnosed by computed tomography scan.

Finally, do I think the operative risk of repairing iliac artery aneurysms is higher than in aortic aneurysms? Yes, I do, in general, by review of the literature. Elective mortality rates as high as 42% have been reported. I think this is because the relative size of iliac artery aneurysms is greater than the relative size of aortic aneurysms. They are deep in the pelvis and difficult to expose. They are often adherent or certainly in close proximity to local venous structures, and with venous bleeding, it can result in a great deal of blood loss and morbidity.

Dr. Ronald L. Dalman (Stanford, Calif.). Those are impressive surgical results, and you are to be congratulated for them.

I would like to add a word of caution about the endovascular option for iliac aneurysm stent grafting. We have growing experience with that procedure, and I will briefly comment on two patients to emphasize the points you have already made.

One patient had a large hypogastric aneurysm that was coil embolized, became symptomatic 2 years later, was restudied and found to be significantly enlarged, and then was excluded by placing a stent graft from the common to the external iliac artery across the origin on the hypogastric. When stent grafts are placed in ectatic iliac artcries, they tend to straighten out the vessel. In this patient, the mass effect actually caused compression of the contralateral iliac artery. The contralateral common iliac arteries then were stented, and subsequently that patient developed a massive iliofemoral deep venous thrombosis ipsilateral to the side of the original hypogastric aneurysm.

We had the same experience in another patient with a 8-cm pseudoaneurysm at the distal anastomosis of an aortobiliac graft. A stent graft was placed across the distal graft into the native external iliac artery, and this caused compression of the contralateral iliac artery. That artery then was stented, and the patient subsequently developed a massive iliofemoral deep venous thrombosis on the side of the original pseudoaneurysm. Both of these events confirm your comment about the lack of space present in the pelvis and the need to evacuate and exclude large lilac aneurysms.

Dr. Krupski. I do not mean to draw any firm conclusions on the basis of just two cases of endovascular treatment. I think that would be unwise, but when you review the literature, it is curious that the two large series, one from the Veith group and one from France, had identical morbidity and mortality rates of 27%.

These were not small complications either. They included several deaths, major hemorrhages, graft occlusions with leg ischemia, amputation, and so on. So, I would encourage you to read those reports and use some caution if you decide to treat these aneurysms by endovascular techniques.

Dr. Ronald J. Stoney (San Francisco, Calif.). I have just one area on which I ask you to expand. Roughly half of your patients had unilateral common iliac aneurysms. We have been unsure how to apply the criteria of selective iliac replacement grafting versus aortoiliac grafting. We have seen patients who were thought to have unilateral iliac aneurysms who, at operation, revealed contralateral iliac arteries that were patulous or aneurysmal.

Our preference is to perform aortoiliac replacement under these circumstances. This practice may not be radical because we have seen patients referred for reoperation a number of years after their unilateral common iliac artery was replaced selectively. They develop. over time, either a contralateral lilac aneurysm or an aortic aneurysm or both. Would you comment on that?

Dr. Krupski. Thank you for your comment, Dr. Stoney. I first became interested in the topic of iliac artery aneuryms when helping you treat several patients with this disorder at the University of California at San Francisco.

Our policy generally is to treat the symptomatic aneurysm or the largest aneurysm and then follow the other side carefully. By protocol, we follow these patients on a yearly basis with computed tomography scans.

I have one point that I would like to make. In general, we like to bring the aortic grafts all the way from the infrarenal aorta and get as close to the renal arteries as possible. Yet, occasionally in these patients who appear to have perfectly normal aortas, I will originate a graft below the inferior mesenteric artery if the inferior mesenteric artery is patent, especially if I have to exclude the hypogastric artery. This is rare, however.

Dr. Carlos Donayre (Los Angeles). I would like to commend you on your paper and results. I think that what you obtained with these aneurysms is admirable, especially in the male pelvis, which can be formidable.

Interestingly, the last two iliac artery aneurysms that I treated were both first seen with hydronephrosis. One patient was a man with internal iliac artery aneurysm who was discovered to have a patent sciatic artery with which we had to deal. The other patient had just an isolated iliac. Both had nephrosis.

What was the incidence rate of hydronephrosis in your series?

My other question asks if you could address your blood loss in this series. I know that in my experience these operations tend to be fairly bloody. I have relied on preoperative embolization of some of the larger aneurysms because I think that improves the blood loss.

Then, I have a comment regarding the endovascular treatment of aneurysms. We do have experience with this. I think that one of the problems with it is that iliac artery aneurysms tend to introduce tortuosity to the vessels, which is a difficult area to treat.

In the initial operations, the vascular approach has been with unsupported stents. I think that now that we have the capability of having a fully supported stent, our results would be better endovascular-wise. I did enjoy your paper.

Dr. Krupski. Thank you for your questions and comments.

Your first question was about our incidence rate of hydronephrosis. Two of these 21 patients were first seen with hydronephrosis. We made no attempt at ureterolysis; we simply repaired the aneurysms. The hydronephrosis disappeared after repair of the aneurysms. So, I do not think it is necessary to perform ureterolysis, but certainly urinary tract symptoms are frequent in these patients.

We did not specifically measure blood loss, but I was quite pleased to find in review of the records that no patient had a major venous injury. By avoiding major venous injuries, our blood loss was quite acceptable.

Finally, with respect to the newer devices, I am sure there are always better mouse traps. Perhaps, in the future, endovascular treatment will be more efficacious in these patients, but I think it remains to be seen in larger series.