

Original papers

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Open Surgery for Abdominal Aortic Aneurysm or Aorto-Iliac Occlusive Disease - Clinical and Ultrasonographic Long-Term Results

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Key words. Abdominal aortic aneurysm ; aorto-iliac occlusive disease ; aortic ultrasound ; prosthesis infection ; pseudo-aneurysm.

Abstract. *Objective :* To determine postoperative and long-term outcome and assess the relevance of abdominal ultrasound (US) after surgery for abdominal aortic aneurysm (AAA) or aortoiliac occlusive disease (AIOD).

Methods : Records of 1704 consecutive patients having graft implantation from 1988 to 2000, either for AAA (n = 1144) or for AIOD (n = 560), were reviewed. In 2006, follow-up was 9180 patients-years for the AAA group and 5450 patients-years for the AIOD group. Among 1006 alive patients, 377 were invited randomly for US and clinical examination.

Results : Hospital death occurred in 99 patients (8.6%) of the AAA group (53% in ruptured and 2% in elective AAA), and in 18 patients of the AIOD group (3.2%). There were 581 late deaths, including eight due to prosthesis infection, one to pseudo-aneurysm rupture, and one to graft thrombosis (0.6% graft-related mortality). Prosthesis thrombosis occurred in 32 patients (26 in AIOD group, $p < 0.001$), and graft infection in 26 (17 in AAA group, $p < 0.01$). Pseudo-aneurysms developed in 90 patients (68 in AIOD group, $p < 0.001$), including eight at the proximal aortic, one at the distal aortic, two at the iliac and 79 at the femoral anastomosis. In the AAA group only, surgery was required for a new thoraco-abdominal and pararenal aneurysm in eight and four patients, respectively, while US evidenced a 26-35 and a 36-50 mm supraanastomotic aortic dilatation in 65 (32%) and in 14 (7%) patients, at a mean follow-up of 10.5 and 9.3 years, respectively.

Conclusion : Long-term results are good after open surgery for AAA or AIOD. Prosthesis infection and anastomotic pseudo-aneurysm are the main causes of graft-related mortality and morbidity, respectively. Because of high incidence of asymptomatic supraanastomotic aortic dilatation, all patients with a history of AAA repair should have regular abdominal US.

Introduction

The new endovascular or laparoscopic approaches used to treat abdominal aortic aneurysms (AAA) or aortoiliac occlusive disease (AIOD) should be precisely evaluated, especially on the long-term. In this regard, the results of such recent techniques should be compared with those of robust series of traditional open techniques. Therefore, we have performed a thorough analysis of the results of all consecutive patients who had surgery in our academic centre from 1988 to 2000. In addition, we aimed at assessing the relevance of systematic abdominal ultrasound (US) examination in asymptomatic patients with a history of abdominal aortic surgery.

Methods

This study was approved by the Ethical Committee of the University Hospital of Liège. All patients that underwent US examination gave written consent.

Records of all 1704 patients who underwent, between January 1, 1988 and December 31, 2000, implantation of a knitted textile vascular prosthesis, tubular or bifurcated, either for AAA (n = 1144) or for AIOD (n = 560), were reviewed (retrospective study). In all AAA patients, the proximal anastomosis was performed in an end-to-end fashion, while in the AIOD group, it was made end-to-end in 117 patients and end-to-side in 443 patients. In the chart review, particular attention was paid to identify the occurrence of anastomotic (aortic, iliac or femoral) events, of prosthesis infections or thrombosis, and of changes occurring in native intra-abdominal arteries.

Furthermore, 377 patients alive in January 2006 and devoid of any graft event, were invited randomly by phone, or written notice to the patient, his (her) relatives, or his (her) family physician, to undergo a free clinical and US examination. Second and third recalls were repeated if necessary. Globally, 60 of the 377 patients (14% of contacted patients) declined the invitation, and 317 (86% of contacted patients and 32% of 1006 alive

patients) were submitted to US and clinical examination; they included 201 in the AAA group (33%), and 116 in the AIOD group (31%).

Sonographic imaging studies were performed with a Toshiba (Toshiba Medical Systems, Europe) echographic scanner, starting in the epigastrium. All patients had been instructed to refrain from drinking and eating for 8 hours. The abdominal aorta and iliac arteries were visualised in transverse and sagittal sections, using a multifrequency three to six MHz sectorial probe (B-mode sonography).

In 30 patients, abdominal intestinal gas obscured the abdominal aorta and graft. A second sonogram was planned a week later after stopping beverage and food intake for 12 hours. Overall, ultrasonography failed to visualise the aortic graft in 12 patients. Morbid obesity ($n = 8$) was the most common cause of insufficient acoustic access to the infrarenal aorta. For these 12 patients, a CT-scan was done as an alternative investigation method. All US-detected intra-abdominal para-anastomotic dilatations were confirmed by a CT-scan control. There were no false positive sonographic study results. There was a strong relation between the diameters obtained by each technique.

Comparisons of nominal variables were performed with χ^2 test or Fisher's exact test, while tailed sample t tests or with Wilcoxon rank sum tests when necessary. Survivorship to death was estimated with the Kaplan-Meier method. A p value < 0.05 was considered statistically significant. Statistical analysis was performed using the software SAS (SAS Institute Inc., Cary, NC, USA).

Results

Hospital mortality was 8.6% (99/1144) in the AAA group, precisely 53% (79/149) in ruptured AAA and 2% (20/995) for elective surgery, while it was 3.2% (18/560) in the AIOD group.

Follow-up of 1587 patients leaving the hospital alive was recorded up to December 31, 2006, and included a total of 9180 patients-years in the AAA group and of 5450 patients-years in the AIOD group. There were 581 late deaths, including ten graft-related deaths, among which eight were due to infection, one to pseudoaneurysm rupture, and one to graft thrombosis. Graft-related mortality was 0.6% (0.4% in AIOD patients and 0.8% in AAA patients). Long-term survival is depicted in Figures 1 and 2. Actuarial survival at 10 and 17 years was 66% and 41% in the AIOD group, and 52% and 32% in AAA patients, respectively.

Graft thromboses

A total of 32 patients (2%) had graft (limb) thrombosis. Among 1045 hospital survivors of AAA surgery, there were two early and four late graft thromboses (0.6%), at a follow-up of one, 1.5, 3, and 5 years, respectively. All these graft thromboses were successfully treated with thrombectomy or cross-over, with no postoperative death and no limb loss.

Among 542 hospital survivors of AIOD surgery, 26 patients (4.8%, $p < 0.001$ compared to AAA group), including four within the first postoperative month, three during the first year and 19 later, developed graft throm-

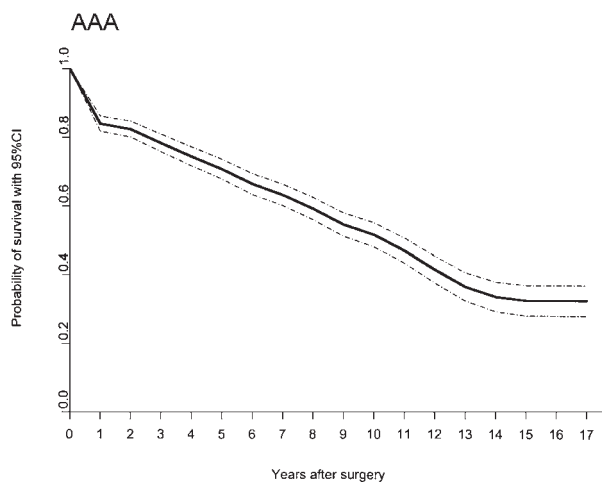


Fig. 1

Actuarial survival curve after surgery for abdominal aortic aneurysm (AAA).

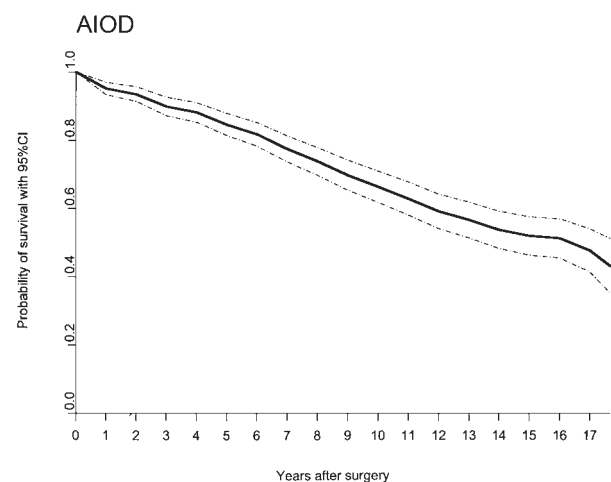


Fig. 2

Actuarial survival curve after surgery for aorto-iliac occlusive disease (AIOD).

basis. It occurred twice in five patients and three times in two. One patient died while two patients required major limb amputation ($p = 0.04$, compared to AAA group).

Infected prostheses

A total of 26 patients, among whom eight died, developed prosthetic infection, including 17 in the AAA group and nine in the AIOD group. Course of these patients is detailed according to clinical presentation, time of occurrence and type of treatment.

Three patients in the AIOD group (none in the AAA group, $p = 0.03$), presented with an aorto-enteric fistula, at a follow-up of three months, 13 years and 14 years, respectively. These patients required surgery, with one postoperative death. Four patients had a proximal aortic infection, including infection of a proximal pseudo-aneurysm in two patients and of a pararenal aneurysm in two patients. All these patients required surgery, with three postoperative deaths. Four femoral pseudo-aneurysms were infected; one ruptured and the patient died postoperatively. Fifteen patients were diagnosed with prosthetic infection but without macroscopic arterial deformities. All were treated surgically and two of them died.

Infection developed within six months of surgery in ten patients (5 in the AAA group), with two postoperative deaths, and later in 16 patients (12 in the AAA group), with five postoperative deaths.

Regarding the type of treatment, no surgery was performed in two patients, in one case because the patient died the day of hospital admission and in the other because the patient was treated with antibiotics alone. Among 13 patients (9 in the AAA group) who were treated with graft resection and orthotopic homograft implantation, two died postoperatively and one two years later secondary to homograft-enteric fistula. Nine patients (5 in the AAA group) had their graft resected with implantation of an extra-anatomic graft, with two postoperative deaths. Two patients with an infected pararenal aneurysm were treated by interposition of a textile graft and died postoperatively.

Anastomotic pseudo-aneurysms

Pseudo-aneurysms (PA) at the proximal anastomosis developed in eight patients (0.5%), including 3 (0.3%) in the AAA group and 5 (0.9%) in the AIOD group, at a mean follow-up of 8.5 years and 6.2 years, respectively. Two of these proximal PA were infected (see above), both among the AAA group, and needed surgical correction. One of these two patients, operated in emergency because of PA rupture, died. There was only one distal aortic pseudo-aneurysm, in the AAA group, which was recognised 12 years after the initial procedure and

successfully corrected surgically. The total incidence of aortic pseudo-aneurysms was 0.3% after end-to-end anastomosis, but was 1.15% after end-to-side anastomosis ($p = 0.03$).

Two patients (0.2%) developed a PA at the iliac suture line, both in the AAA group, 11 and 12 years after surgery, respectively. None was infected and both were surgically corrected, with one postoperative death.

Femoral pseudo-aneurysms were numerous and developed in 16 patients (1.5%) of the AAA group and in 63 patients (11.6%) in the AIOD group ($p < 0.001$), at a mean follow-up of 12.9 years and 11.3 years, respectively. Four femoral PA were infected, including three in the AAA group. One of these PA ruptured and the patient died after surgical intervention.

New aneurysms

New aneurysms were found only in the AAA group. At a mean follow-up of 10.3 years, eight patients developed a thoraco-abdominal aneurysm, among whom 6 required surgery. All patients survived, including one that presented with aneurysmal rupture. Four patients, at a mean follow-up of 11.9 years, developed a pararenal aneurysm, requiring surgical correction. Among these, two patients who were operated urgently because of aneurysmal rupture, died. Among 11 common iliac artery aneurysms (diameter > 30 mm) diagnosed at a mean follow-up of 8.2 years, 4 required surgery, including one in ruptured conditions. All patients survived.

Five type A and nine type B aortic dissections occurred during follow-up, at a mean time of 6.1 years and 5.2 years, respectively. All type A aortic dissections were treated surgically while all type B were submitted to medical treatment. All 14 patients survived.

Systematic late US examination

Among 317 patients who had a US examination at follow-up, 116 were initially operated for AIOD and 201 for AAA. No significant anomaly was found in any AIOD patient. Among the screened AAA patients, 7 were found to have a dilated common iliac artery (diameter > 30 mm) at a mean follow-up of 7.2 years. All these seven patients are now followed with regular US examination.

In 79 AAA patients, the abdominal aorta, proximal to the anastomotic site, was found dilated, with the largest diameter measured between 26 and 35 mm in 65 patients (32% of all US screened AAA patients), and between 36 and 50 mm in 14 patients (7%), at a mean follow-up of 12.5 years and 9.3 years, respectively. No prophylactic surgery has yet been proposed to these 14 patients with a small proximal aortic aneurysm, but all are now followed by regular US examination.

Table 1
 Comparison of complications observed in our series with those of two older series (5, 6) (AIOD) and three more recent series of AAA (2-4)

First Author (ref.)	Initial surgery	Inclusion period	n. of patients	Graft thrombosis	Graft infection	Aorto-enteric fistula	Anastomotic pseudo-aneurysm				Graft-related mortality	Adjacent new aneurysm					
							upper aorta	lower aorta	iliac	femoral		thoraco-abdom.	para-renal	iliac > 30 mm			
SZILAGYI (5)	AIOD	54-83	1647	19.0%	1.8%		0.21%			5.7%	8.4%						
		1. 54-63		12.4%	1.6%												
		2. 64-73 3. 74-83		8.4%	0.9%												
NEVELSTEEN (6)	AIOD	63-88	869	16.0%	2.3%	0.9%	1.50%				3.2%** 6.1%						
Our series	AIOD	88-00	560	5.2%	1.6%	0.5%	1.10%					13.2%	0.4%				
	AAA	88-00	1144	0.6%	1.7%	0	0.30%	0.10%	0.20%			1.6%	0.8%	0.8%	0.4%	1.0%	
HALLET (2) (Olmsted county)	AAA	57-90	307	2.0%	1.3%	1.6%	1.00%	0	0		2.1%	2.6%	NR	NR	NR	NR	
BIANCARI (3) (Finland)	AAA	79-90	208	5.3%			2.90%	0.50%	0		8.2%	8.2%	3.0%	5.0%	1.0%	1.0%	
ADAM (4) (South Australia)	AAA	82-03	1256	1.0%	0.5%	0.2%	0.08%	0.08%	0.16%		0.6%	0.4%	NR	0.08%	0.16%	0.16%	

AIOD, aorto-iliac occlusive disease ; AAA, abdominal aortic aneurysm ; NR, not reported.

Discussion

From the very beginnings of vascular graft implantation for AAA or AIOD, complications such as graft thrombosis, prosthesis infection and anastomotic pseudoaneurysms, eventually leading to rupture, have been recognised (1). Many reports have addressed the results of patients treated either for AAA (2-4) or AIOD (5, 6), while others have focused on patients with specific pathologies referred from several centres. Three reports (2-4) included in Table I shared some similarities with our own series, because they are devoted to graft-related complications in a large population of patients having surgery for AAA in one centre, the hinterland of which was clearly topographically delimited. Nevertheless, the specificity of our study was to compare complications among a large series of consecutively treated patients, for AAA or AIOD, in one single centre. Our series started in 1988 for the sake of homogeneity in surgical techniques and nature of the vascular textile graft implanted (knitted and collagen coated). Moreover, we stopped the inclusion period in December 2000, so that the survey initiated in 2006 would include patients with at least a 5-year follow-up.

We observed an incidence of (limb) graft thrombosis of 2%, mostly in patients that had surgery for AIOD, with multiple occurrences in several cases. However, this complication was less frequent in our experience, as compared to other series (1, 3, 6). For both series (1, 6) that included patients with AIOD, patient inclusion was made before 1988, prior to the beginning of our own series. This could be one possible explanation for this difference. Nevertheless, a question rises as whether our follow-up data were complete, without bias. Indeed, only one third of survivors benefitted from the systematic clinical and ultrasound examination, while we obtained follow-up informations by chart review and written informations for all patients. Therefore, the number of thrombosed grafts may have been undervaluated because of possible lack of symptoms in elderly patients and by the fact that this complication could have been treated in community hospitals.

The incidence of infection in our series was equivalent to the one reported in older series (1, 6) but higher compared to more recent ones (2-4). We found no significant difference in the incidence of infection among AAA or AIOD patients, although there were more inguinal infections in the AIOD group. Specific aspects of graft infection have been widely analysed (7-13). Despite precise prophylactic rules, prosthesis infection still occurs with an on-going debate about the optimal treatment. It should be emphasised that infection can be responsible for the development of pseudoaneurysms, because of collagenase production. In such cases, early diagnosis is mandatory, before pseudoaneurysm rupture occurs.

However, in elderly patients with insufficient medical care, the infection may not be diagnosed before rupture.

In our series, there were 22 (1.9%) anastomotic pseudoaneurysms in the AAA group, among which five were infected, at a mean follow-up of 8.5 years at the proximal aortic anastomosis and of 12.9 years at the femoral anastomosis. These results were similar to those reported by other series (2-4), except for a higher incidence of femoral PA in the Finnish series (3) and a much lower in the Australian series (4). Mean time before diagnosis was longer in our series and the incidence of infection higher, clearly split in early (29%) and late (71%) infections. This differs markedly from the results reported by HALLETT *et al.* (2), with all infections occurring early after surgery, at a mean time of 0.2 years. Furthermore, we observed a high (11.6%) incidence of femoral pseudoaneurysm in AIOD patients.

Aneurysmal transformation not related to the anastomosis (i.e. new aneurysms) developed in 23 AAA patients (2%), with four ruptures. New true aneurysms of the upper supra-anastomotic aorta and pseudoaneurysms have been analysed together by some authors (14-16), under the denomination of paraanastomotic aortic aneurysms (14). We observed proximal aortic pseudoaneurysms with a relatively similar incidence among AAA and AIOD patients. On the opposite, new aneurysms were seen only in patients that had been operated on for AAA. This observation is not surprising because any portion of the aorta in AAA patients is *a priori* genetically prone to aneurysmal dilatation. Furthermore, technical problems such as a too large neck proximal to the anastomosis may increase the risk of later aneurysm development. Nature of the prosthesis and of the suture material (5) was no longer a problem in recent series. In particular, our series was homogenous in respect to the textile graft used, knitted and collagen coated (Vascutek in about 80%, and other but similar prostheses in 20%). Operative mortality following repair of pararenal aneurysms varied from 21 to 37.5% (14, 15, 17), while mortality for ruptured cases varied from 22 to 70% (15-18).

The most remarkable finding of this study was the high number of supra-anastomotic aorta dilatations discovered by systematic US screening. Among the 201 AAA patients having undergone US examination, a 26-35 and a 36-50 mm supraanastomotic aortic dilatation was evidenced in 65 (32%) and in 14 (7%) patients, at a mean follow-up of 10.5 and 9.3 years, respectively. Using translumbar aortography, LIPSKI & ERNST (19) observed a mean aortic dilatation of 1 mm after 42 months, while 21 patients (8%) had a dilatation larger than 5 mm. Obviously, this arteriographic method analysed only the patent lumen of the aorta and therefore likely underestimated its true diameter. With CT-scan, ILLIG *et al.* (20) measured the aortic diameter in

97 patients and observed that, after 89 months, the infrarenal aortic diameter increased by a mean of 4.3 mm. While supra-anastomotic dilatations larger than 30 mm were scarce in their series, they seemed to concur with the preoperative diameter of the neck. This possible correlation could not be demonstrated in our series because not every patient underwent a preoperative evaluation in our hospital.

While diagnosis of femoral pseudo-aneurysms is usually obvious, intra-abdominal pseudo-aneurysms are difficult to diagnose, with an incidence diversely estimated (16-18, 21, 22). Too often, the first clinical manifestation of pseudo-aneurysm is rupture. Therefore, several authors suggested systematic annual screening by US (23, 24) or CT-scan (25). EDWARDS *et al.* (16) favoured annual US examination in patients with an aortic graft. TREIMAN *et al.* (17) reported three patients with a proximal pseudo-aneurysm of less than 5 cm in diameter that enlarged rapidly, and even, ruptured in one case. KALMAN *et al.* (25) advised annual CT-scan 5 years after initial surgery. LIAPIS *et al.* (23), reporting an annual increase of the neck diameter of 0.57 mm after a mean time of 4.7 years, recommended annual US examination after the first five postoperative years.

However, based on a strict cost-effectiveness analysis, POST *et al.* (26) recommended to restrict systematic ultrasound screening to patients with aorto-bi-iliac prostheses aged 54 or younger, to be started only 10 years after surgery. They advised a similar strategy for older patients only if mortality for secondary intervention was lower than 2%. Finally, these authors (26) did not recommend routine US screening for patients with aortic tube or aorto-bi-femoral prostheses. We do not share this view because of the high number of aneurysmal dilatations of the supra-anastomotic aorta detected in our patients by a US screening. It should be emphasised that, after a mean time of nine years, the incidence of supra-anastomotic dilatation, with a diameter between 36 and 50 mm, was 7%. This was within the range of which TREIMAN *et al.* (17) had reported the case of one rupture in a rapidly expanding aortic dilatation. There was, of course, a substantial difference between the large number of aneurysmal anomalies detected by US screening and the reported incidence of rupture, both in our series and in the literature. Probably, most of these aneurysmal dilatations will never rupture, either because of a slow growth or because the patient will die from other causes. Nevertheless, like several others authors (14-17, 23-25) recommended, we strongly support a systematic screening of asymptomatic patients previously operated on for AAA.

For patients that had surgery for AAA, another important reason for systematic US screening is the genetic tendency of any aortic segment to undergo aneurysmal transformation that may develop upstream in the thora-

co-abdominal aorta or downstream in common or internal iliac arteries. Several endovascular methods now exist to treat these complications (27-29). Apart from intervention, open or endovascular, a drug regimen with statins, slowing the growth of aneurysms by inhibition of the parietal metalloproteases, should also be started in these patients (30).

In conclusion, long-term results are good after open surgery for abdominal aortic surgery or aorto-iliac occlusive disease. Prosthesis infection and anastomotic pseudo-aneurysm are the main causes of graft-related mortality and morbidity, respectively. Because of the high incidence of supraanastomotic aortic dilatations, we believe that all patients that had a history of AAA surgery should have regular abdominal US examination.

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