ORIGINAL ARTICLE

Morbidity and Mortality of Reconstructive Surgery of Noninfected False Aneurysms Detected Long After Aortic Prosthetic Reconstruction

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Objective: To determine the morbidity and mortality of surgical treatment of false (anastomotic) aneurysms, we analyzed the results of 158 consecutive surgical procedures for repair of false aneurysms that were detected as a result of a surveillance program after aortic reconstruction with a prosthesis.

Design: Retrospective analysis of patient data from a vascular registry that included information on the long-term follow-up of our patients.

Setting: A university hospital (tertiary referral center) in the Netherlands that has been performing vascular reconstructive surgery since 1958.

Patients: We performed 158 surgical procedures on 135 patients with 220 noninfected false aneurysms. Using a yearly surveillance program, the false aneurysms were detected at a mean interval of 8 years after the initial reconstruction. Most patients (60%) were asymptomatic. The operation was performed as an emergency in 25 instances (16%).

Results: The mortality rate of patients receiving nonsurgical treatment was very high (61%) owing to documented rupture (11 of 18 patients). The intraoperative death rate was 7.6% per procedure. This was higher for emergency (24%) than for elective procedures (4.5%).

Conclusions: Conservative follow-up carries a very high mortality rate, as does emergency surgery for a false aneurysm. However, the intraoperative mortality rate of elective reconstruction of a false aneurysm can be in the same range as that of elective primary aortic reconstruction. Therefore, we advocate a surveillance program, including yearly ultrasound studies, after prosthetic aortic reconstruction for the timely detection and elective repair of all false aneurysms.

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FALSE OR anastomotic aneurysms may occur as a late complication after aortoiliac and aortofemoral reconstruction with a prosthesis. The reported prevalence varies between 2% and 29%, depending on how prevalence is calculated, method of screening used, duration of the follow-up period, and number of patients lost to follow-up.[1-5] The cumulative incidence of false aneurysm increases with time after the primary reconstruction. In a previous study of long-term results after aortic reconstruction,[1] we have demonstrated that the actuarial cumulative incidence of false aneurysms was 23% at 15 years after surgery, a finding that was confirmed by others[4] who reported an incidence of 27% after 15 years. False aneurysms may cause morbidity and mortality, although their frequency is not precisely known. It is important to balance the potential benefits of repair against the risks of surgery, especially for small false aneurysms. These patients are more than 10 years older than they were at the time of primary reconstruction. This implies that the cardiopulmonary risk of the repair procedure is probably increased as compared with the risk of the primary reconstruction. Data on the operative risk and outcome of surgical reconstruction of false aneurysms after aortic reconstruction are limited.[5-10] To evaluate the risk and results of surgical repair of false aneurysms at the aortic, iliac, and femoral anastomotic sites, we have analyzed the results of a consecutive series of 158 operations in 135 patients with 220 false aneurysms after aortoiliac or aortofemoral prosthetic reconstructions retrieved from our vascular registry.[11] Most aneurysms were detected by means of a surveillance program, though some patients who required emergency treatment presented at times different from their schedule of follow-up.

RESULTS

EARLY RESULTS

There were 12 operative deaths, accounting for an operative mortality rate of 7.6% (**Table 3**). Intraoperatively, 1 patient died of rupture of the false aneurysm and 1 died of bleeding during a reintervention pro-

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PATIENTS AND METHODS

Between 1963 and 1990, a total of 240 false aneurysms after aortoiliac or aortofemoral reconstruction were found in 153 patients. The presentation of these false aneurysms varied widely. Most (60%) of the patients were asymptomatic, but 17 (10%) presented with bleeding due to rupture of the false aneurysm. Other symptoms included pain (11%), a pulsating mass (8%), or both (8%). In 3% of these patients, the presenting symptoms could not be retrieved from the patient's medical record. Multiple false aneurysms were found in 19 patients (12%). The 240 false aneurysms that were first found were evenly distributed among the various anastomotic sites (aortic, 31%; iliac, 38%; and femoral, 31%).

Of the 153 patients, 135 patients underwent 158 procedures for repair of 220 false aneurysms. Excluded from analysis were 18 patients (20 aneurysms) who did not undergo surgery. Of these, 11 died preoperatively—8 of a documented rupture of the false aneurysm a mean of 6 years (range, 1-15 years) after the initial operation, and 3 of unknown causes while awaiting repair of the false aneurysm. Seven patients did not undergo surgery for various reasons (**Table 1**). Of the 135 patients undergoing surgery, 17 had multiple procedures for repair of false aneurysms during long-term follow-up, accounting for a total of 158 operations (12 patients underwent a second operation, 4 patients underwent 3 operations, and 1 patient underwent 4 operations).

The study group of 135 patients was composed of 122 men and 13 women with a mean age of 62 years (range, 36-86 years). The mean interval between the initial aorta reconstruction and the detection of a false aneurysm was 8 years (range, 0-25 years). The indication for the initial operation was obstructive disease in 73% and aneurysmal disease in 27% of patients.

Detection of false aneurysms after surgery was accomplished by a surveillance program. After the initial operations, patients were routinely seen at 3, 6, 12, and 24 months and then at yearly intervals for the rest of their lives. Vascular reconstruction was previously evaluated by physical examination, but in 1978 abdominal ultrasound studies were added to routinely examine all prosthesis-to-artery anastomoses. Angiography or computed tomographic scanning was done when ultrasonography results were of poor quality or when reoperation was being considered. The presence of a false aneurysm was always considered an indication for surgery, although some small femoral aneurysms in the groin were occasionally followed up nonsurgically if the patients refused repair.

The initial reconstruction had been an aortoiliac reconstruction in 68% of patients and an aortofemoral reconstruction in 32%. As published previously,[1] the proximal anastomosis was usually performed in an end-to-end configuration and distal anastomoses were performed in an end-to-end or end-to-side configuration, depending on the type of lesion, with a running suture. Silk sutures were used until 1966, and braided Dacron until 1977, for 94 and 74 anastomoses, respectively. From 1977 on, all the anastomoses (72) were performed with monofilamentous polypropylene sutures. Thus, 39% of the false aneurysms were associated with silk-sutured anastomoses. Before 1964, we used Teflon and Dacron prostheses, but after 1964 knitted Dacron velour prostheses were used exclusively.[1,12-14]

Bacterial cultures, obtained routinely during all surgical procedures, were all negative. Sonicated graft cultures were not performed.

OPERATIVE RISK FACTORS

A total of 158 operations were performed in 135 patients (17 patients underwent another operation during follow-up for cedure immediately after the operation. Postoperatively, 10 patients died of various causes (**Table 4**).

Operative mortality was not significantly influenced by the patient variables (Table 3). However, mortality was clearly influenced by the operative variables. The mortality rate of emergency procedures was 24% (6 of 25 patients), of which 1 was done for a ruptured false aneurysm of a femoral anastomosis. This patient died of cardiac arrest on the first postoperative day. The mortality rate of elective procedures was only 4.5% (6 of 133 patients). The mortality rate of local procedures was 5.3% (5 of 94 patients). For extensive procedures, the mortality rate was 8.5% (5 of 59 patients). One patient died after ligation of the artery and another patient died of a rupture of a false aneurysm that was considered beyond repair.

The intraoperative morbidity rate of the patients surviving the operation was 17% (26 of 156 patients) (**Table 5**). Intraoperative bleeding was the most frequent and serious complication, occurring in 18 cases, and was mostly associated with emergency procedures. The false aneurysm ruptured in 2 cases during the operation. Bleeding from the renal vein and the spleen was another complication. The intraoperative morbidity rate was 32% for emergency procedures (8 of 25 patients) and 14% for elective procedures (18 of 131 patients) ($P<.03$).

The postoperative morbidity rate of the patients surviving the operation was 53% (82 of 156 patients). As expected, emergency procedures were associated with a higher postoperative morbidity rate (70%) than were elective procedures (50%) ($P<.05$). Fifty-four patients (58%) experienced morbidity after local procedures and 26 (44%) after extensive procedures.

Reinterventions in the immediate postoperative period were required after 22 procedures, resulting in a reintervention rate of 14.1% (22 of 156 patients) per procedure. In 15 of these reinterventions it was not necessary to revise the reconstruction. In 3 cases a revision was performed for thrombosis of the graft and in 1 case for graft infection. The major amputation rate (above or below the knee) was 2.6% (4 of 156 patients), of which 1 amputation was necessary after ligation of the artery.

LATE RESULTS

Forty-two patients who underwent surgery died during follow-up. Three patients died within 1 year and 39 died more than 1 year after discharge from the hospital. Most patients died of myocardial infarction or stroke. Early in the series 1 patient died of a ruptured false aneurysm, 2 months after an explorative laparotomy in which it was concluded that this false aneurysm could not be repaired. The mean interval between surgery and death was

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a newly developed false aneurysm). Therefore, the results will be presented per operation rather than per patient. To study morbidity and mortality, we analyzed whether risk variables influenced the outcome. Two types of risk variables were analyzed: those related to the general physical condition of the patient (patient variables)[15-17] and those directly related to the surgical procedure (operative variables).

The patient variables studied were hypertension, previous myocardial infarction, angina pectoris, renal function, cerebrovascular disease, and obstructive pulmonary disease. Hypertension, defined as a diastolic blood pressure measurement of more than 100 mm Hg or treated with antihypertensive drug therapy, was present in 74 patients (47%). A myocardial infarction within 3 months before the false aneurysm repair procedure had occurred in 3 patients, and 30 patients had had a myocardial infarction longer than 3 months prior to the procedure. Mild (serum creatinine level >1.5 mg/dL [>133 µmol/L], 13 patients) or severe renal dysfunction (serum creatinine level >2.0 mg/dL [>177 µmol/L], 5 patients, 3 of whom were dependent on hemodialysis) was present in 18 patients (11%). Twelve patients had had a previous stroke and 7 patients had had a transient ischemic attack. Obstructive pulmonary disease was present in 29 patients (22%). Mild (vital capacity and/or forced expiratory volume in 1 second reduced by not more than 50% from normal) or severe obstructive pulmonary disease (vital capacity and/or forced expiratory volume in 1 second reduced by more than 50% from normal) was present in 23 (17%) and 6 (4%) patients, respectively.

The surgery-related risk variables studied were the timing (emergency or elective) and extent of the operation (local repair or extensive procedure). There were 133 elective operations performed and 25 emergency procedures for a ruptured false aneurysm. In 94 of the 158 operations, a local procedure could be done. This included partial resection of the prosthetic graft and a part of the arterial wall, when necessary, and reconstruction by interposition with a vascular prosthesis. In 59 cases more extensive operations were performed. In these cases, the complete prosthesis was removed, followed by reconstruction with a new vascular prosthesis. An additional reason for a more extensive reconstruction was dilatation or elongation of the old prosthesis. In 5 cases a reconstruction was not performed. Simple ligation of the artery was done for 3 false aneurysms, 1 patient died intraoperatively of rupture of the false aneurysm, and in 1 case it was decided that the false aneurysm could not be repaired (**Table 2**).

Operative morbidity was expressed as the complication rate per operation and operative mortality as the death rate per operation. All morbidity and mortality occurring during the hospital stay was included.

FOLLOW-UP

The method of follow-up after repair for a false aneurysm was similar to the follow-up after the initial operation. Follow-up included yearly serial ultrasonographic studies, because it was anticipated that the risk of a second false aneurysm after the repair procedure might be increased. At the end of the study period, 35 patients were alive and being followed up after repair of a false aneurysm (mean follow-up time, 3.4 years; range, 1-13 years), 42 patients had died, and 46 patients had become lost to follow-up (mean follow-up time, 2.8 years; range, 0-16 years). Thus, 77 (63%) of 123 patients had complete follow-up after repair of a false aneurysm.

All data were stored in a computerized vascular registry. For analysis, we used the Number Cruncher Statistical System software program (version 5.0).[18] For evaluation of statistical significance, χ^2 tests on 2×2 tables were used. Differences were considered statistically significant if $P<.05$.

4.2 years (range, 0-16 years). The recurrence rate of false aneurysms was 9.5% (15 of 158 patients), after a mean time of 4.7 years (range, 0-16 years). However, the follow-up was not complete for all patients and this should be considered a minimum recurrence rate rather than an absolute result obtained for this patient cohort.

COMMENT

A false or anastomotic aneurysm is considered an infrequent complication of aortic reconstruction with a prosthesis. In fact, the incidence early after the procedure is very low, ranging from 1% to 6% both in our experience and that of others. However, during long-term follow-up, the incidence of false aneurysms substantially increases.[1,5] The suture material used for the anastomosis is a well-known factor in the development of false aneurysms.[19] The use of silk sutures, which are known to have problems with degeneration, contributed significantly to the prevalence of false aneurysms early in this series. However, as seen in our series, false aneurysms may also occur after using stable suture material. Dangerous complications of false aneurysms are rupture and thrombosis, which may result in loss of life or limb. This is clearly shown by our observation that 8 patients died of a documented rupture of the false aneurysm during follow-up and by the death of a patient whose aneurysm was considered beyond repair. Treiman et al[9] had a similar experience: they followed up 3 patients with small (<4 cm in diameter) anastomotic or false aneurysms, and noted that the aneurysms all enlarged in less than 1 year and 1 ruptured. Expansion and rupture of false aneurysms have also been observed by others.[10]

In our study, the mean interval between the initial operation and complications was around 8 years; this is an interval when the presence of a false aneurysm is often not suspected in asymptomatic patients. This finding is confirmed by the results of Allen et al,[8] who recommended an ultrasonographic examination 5 years after the original aortic prosthetic reconstruction. These findings emphasize the significant risk of developing a false aneurysm and strongly support a follow-up and surveillance program for the early detection and treatment of this complication.

We found that reconstruction of false aneurysms was associated with significant morbidity and mortality. Our overall mortality rate was 7.6% per operation, which is much higher than the mortality rate of primary reconstructions performed in our institution.[12,17,20] In our study, mortality was not clearly associated with the presence or absence of patient-related risk factors such as hypertension, cardiac disease, renal disease, and cerebrovascular disease, and no patients with false aneurysms were excluded from surgical treatment because of the presence of risk factors after

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Table 1. Patients With a False Aneurysm Undergoing Surgery and Follow-up

Therapy	No. of Patients
Surgery*	135
Followed up (no surgery)	18
Contraindications for surgery	3
Preoperative death†	11
Thrombosis	2
Unknown	2
Total	**153**

*A total of 135 patients underwent 158 surgical procedures.
†Death was caused by a ruptured false aneurysm in 8 cases.

Table 2. Type of Procedure for Repair of False Aneurysms

Type of Procedure	No. of False Aneurysms	No. of Operations
Local*	110	94
Extended†	103	59
Ligation	3	3
Exploration	4	2
Total‡	**220**	**158**

*Partial resection of the Dacron graft and interposition with a new vascular prosthesis.
†Removal of the entire prosthesis followed by reconstruction with a new vascular prosthesis.
‡Multiple false aneurysms were repaired during the same operation.

Table 3. Mortality in 135 Patients Who Underwent 158 Operations for Repair of False Aneurysms

Risk Factors	Operations, No. (%)	Deaths, No. (%)
Timing		
Emergency	25 (16)	6 (24)
Elective	133 (84)	6 (4.5)
Procedure		
Local	94 (60)	5 (5.3)
Extensive	59 (37)	5 (8.5)
Ligation	3 (2)	1
Exploration	2 (1)	1
Patient*		
Hypertension	74 (47)	7 (9)
Myocardial infarction	33 (21)	4 (12)
Renal failure	18 (12)	3 (17)
Pulmonary failure	34 (22)	0 (0)
Stroke	19 (12)	2 (11)

*A combination of risk factors was present in 47 patients.

the early years. Hollier et al[16] reviewed the operative mortality of 106 "high-risk patients" who underwent conventional elective (true) aneurysm repair between 1980 and 1985. They reported a mortality rate of 5.7% that was almost entirely related to cardiac causes.[16] In our study, mortality was particularly associated with emergency procedures performed because of rupture, with associated retroperitoneal or intraperitoneal bleeding. In this respect, our mortality rate of 24% for these emergency procedures is high but lower than that reported by others.[8-10] It is certainly lower than the mortality rates reported for repair of ruptured aortic aneurysms. For proper comparison with other studies, the general condition of the patient, especially the duration of hypovolemic shock, should be considered; however, these factors are usually not reported in the literature. We found that elective repair of a false aneurysm can be performed with a reasonably low mortality rate of 4.5%, which is less than the 8% to 11% reported by others.[8-10] Surprisingly, the mortality rate of these operations, when electively performed, is comparable with that of elective aortic reconstruction.[8,9,17,21,22] This is in spite of the fact that the patients were a mean of 8 years older than they were at the initial operation. It is difficult to compare mortality rates of the first elective operation with the mortality rate of the repair operation several years later. However, it is reasonable to expect that these patients' general vascular conditions deteriorated with time, resulting in a higher operative risk. A satisfactory explanation for the relatively low mortality rate is difficult, but one might speculate that the patients represent a selection of the fittest patients who survived the initial operation and a certain period of follow-up necessary to be at risk of false aneurysm. An additional explanation is the improvement in anesthesiological and surgical techniques.

Table 4. Causes of Death Related to Surgical Repair of False Aneurysms

Causes of Death	No. of Deaths
Cardiac arrest	5
Hemorrhage	3
Rupture of false aneursym	1
Aortic-enteric fistula	1
Renal failure	1
Multiple organ failure	1
Total	**12**

Table 5. Morbidity of 156 Operations for Repair of False Aneurysms in 133 Patients*

Risk Factors	Operations, No. (%)	Complications, No. (%)
Timing		
Emergency	23 (15)	16 (70)
Elective	133 (85)	66 (50)
Procedure		
Local	94 (60)	54 (58)
Extensive	58 (37)	26 (44)
Ligation	3 (2)	1
Exploration	1 (1)	1
Intraoperative complications		
Yes	26 (17)	21 (81)
No	130 (83)	61 (47)

*The patient cohort of 135 patients underwent 158 operations but 2 patients died intraoperatively. Thus, 133 patients, who underwent 156 operations, were available to evaluate the postoperative morbidity. Two intraoperative deaths were excluded because these patients could not have been at risk of postoperative complications.

Not only mortality but also morbidity were associated with the timing of the procedure and the occurrence of intraoperative bleeding. This again underlines that false aneurysms should be repaired at an elective stage. The relatively high postoperative morbidity of 58% af-

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ter local procedures can be explained by the large number of emergency procedures in this group.

In our view, the rationale for elective repair of false aneurysms after prosthetic reconstruction of the aorta is not essentially different from that of a true abdominal aneurysm. Since the prognosis of a ruptured abdominal aortic aneurysm is very poor (75%-90% mortality), elective repair of the aneurysm soon after detection is advocated if the aneurysm is larger than 4 to 5 cm in diameter. To this end, several screening programs for abdominal aneurysms have been proposed.[23] The final decision on whether to advise an asymptomatic patient to accept the immediate risk of operative mortality in exchange for expected additional years of survival is the usual dilemma faced by the surgeon who advises elective prophylactic operation.[24] This study demonstrates that a false aneurysm may rupture, resulting in a very significant mortality rate of 61%. Therefore, we believe that each false aneurysm, irrespective of diameter, should be treated surgically. Moreover, we believe that these more difficult procedures should be performed by experienced vascular surgeons.

It is surprising that not much attention has been paid to the early detection of false aneurysms after aortic reconstruction with a prosthesis. The results of this study clearly support the early detection and surgical treatment of false aneurysms. The only method to accomplish this is careful and complete surveillance. There are various explanations for the lack of such a routine surveillance program in most institutions. First, the risk of rupture in the first few years after aortic prosthetic reconstruction is relatively low. Second, after more than 5 years, patients are often asymptomatic and may be not motivated to participate in a surveillance program. Other reasons could be distance from the outpatient clinic or lack of motivation on the part of physicians. To date, it is not clear which test is the most effective and efficient technique of screening patients for the presence of a false aneurysm. We have always favored physical examination combined with ultrasonography because this approach is both simple and cost-effective, although the sensitivity and specificity of ultrasonography in detecting a false aneurysm is not precisely known.

The amputation rate in this series is small and comparable to that in other studies,[5-7] which report amputation rates of 0% to 12%. An explanation might be that other series include cases of graft infection, a category excluded in our series. These differences in patient characteristics preclude a reliable comparison.

The findings from this study should have important implications for our attitude towards the follow-up of patients after primary aortoiliac and aortofemoral prosthetic reconstructions. False aneurysms after aortic reconstruction with a prosthesis may rupture and the incidence of this event may be higher than previously thought. Because this complication is associated with a high mortality rate, early detection and aggressive elective surgical therapy are indicated. The importance of early detection is emphasized by the high morbidity and mortality rates of emergency procedures and the relatively low intraoperative mortality of elective procedures. In the near future, it seems reasonable to expect that some of these complications could be treated by reconstruction with an endoprosthesis.[25] Because most patients with false aneurysms are asymptomatic, we strongly believe that continuous surveillance and screening of these patients is indicated. A yearly ultrasonographic study seems a reasonable proposal.

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