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## IMMEDIATE REPAIR COMPARED WITH SURVEILLANCE OF SMALL ABDOMINAL AORTIC ANEURYSMS

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### ABSTRACT

**Background** Whether elective surgical repair of small abdominal aortic aneurysms improves survival remains controversial.

**Methods** We randomly assigned patients 50 to 79 years old with abdominal aortic aneurysms of 4.0 to 5.4 cm in diameter who did not have high surgical risk to undergo immediate open surgical repair of the aneurysm or to undergo surveillance by means of ultrasonography or computed tomography every six months with repair reserved for aneurysms that became symptomatic or enlarged to 5.5 cm. Follow-up ranged from 3.5 to 8.0 years (mean, 4.9).

**Results** A total of 569 patients were randomly assigned to immediate repair and 567 to surveillance. By the end of the study, aneurysm repair had been performed in 92.6 percent of the patients in the immediate-repair group and 61.6 percent of those in the surveillance group. The rate of death from any cause, the primary outcome, was not significantly different in the two groups (relative risk in the immediate-repair group as compared with the surveillance group, 1.21; 95 percent confidence interval, 0.95 to 1.54). Trends in survival did not favor immediate repair in any of the prespecified subgroups defined by age or diameter of aneurysm at entry. These findings were obtained despite a low total operative mortality of 2.7 percent in the immediate-repair group. There was also no reduction in the rate of death related to abdominal aortic aneurysm in the immediate-repair group (3.0 percent) as compared with the surveillance group (2.6 percent). Eleven patients in the surveillance group had rupture of abdominal aortic aneurysms (0.6 percent per year), resulting in seven deaths. The rate of hospitalization related to abdominal aortic aneurysm was 39 percent lower in the surveillance group.

**Conclusions** Survival is not improved by elective repair of abdominal aortic aneurysms smaller than 5.5 cm, even when operative mortality is low. (N Engl J Med 2002;346:1437-44.)

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**E**ACH year in the United States, 9000 deaths result from rupture of abdominal aortic aneurysms.<sup>1</sup> Another 33,000 patients undergo elective repair of asymptomatic abdominal aortic aneurysms to prevent rupture, which results in 1400 to 2800 operative deaths.<sup>2,3</sup> Because most abdominal aortic aneurysms never rupture,<sup>4</sup> elective repair is undertaken only when the risk of rupture is considered high. The strongest known predictor of rupture is the maximal diameter of the aneurysm.<sup>5,6</sup> Elective repair has been recommended for patients with aneurysms of 4.0 cm or more in diameter who do not have medical contraindications,<sup>7</sup> although others have advocated the use of surveillance by means of imaging until the diameter reaches 5.0 cm or 6.0 cm.<sup>8,9</sup> As a result, surgery for small abdominal aortic aneurysms has been considered one of the areas of vascular surgery that is most in need of randomized trials.<sup>10,11</sup>

We undertook a randomized clinical trial to determine which of two strategies resulted in a higher rate of survival for patients with small abdominal aortic aneurysms: immediate open surgical repair or surveillance with ultrasonography or computed tomography

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\*Other participants in the study group are listed in the Appendix.

(CT) with repair reserved for aneurysms that enlarged or became symptomatic.

## METHODS

### Study Design

Details of the study methods have been published previously.<sup>12</sup> The study was approved by the human research committees of the coordinating center and each participating center.

Patients were identified through referral and an ultrasonographic screening program that has been described previously.<sup>13,14</sup> Eligible patients were 50 to 79 years of age and had abdominal aortic aneurysms that measured 4.0 to 5.4 cm in diameter by CT within 12 weeks before randomization. Patients were ineligible if they had previously undergone aortic surgery or if they had evidence of rupture of the aneurysm; an expansion of the aneurysm of 1.0 cm or more in the past year or 0.7 cm or more in the past six months; suprarenal or juxtarenal aortic aneurysm (defined by an anticipated need for reimplantation of a main renal artery); a known thoracic aortic aneurysm of 4.0 cm or more in diameter; a probable need for aortic surgery within six months, other than repair of the abdominal aneurysm; severe heart, lung, or liver disease<sup>12</sup>; a serum creatinine concentration of 2.5 mg per deciliter or higher; a history of a major surgical procedure or angioplasty within the previous three months; expected survival of less than five years; severe debilitation; an inability to give informed consent; or a high likelihood of noncompliance with the protocol. The vascular surgery team at each participating center agreed to invite all eligible patients to enroll.

### Randomization and Management

Randomization was designed with equal probability of assignment to each of the two groups by means of a computer-generated random-number code and was tamper-proof, blocked, and stratified according to medical center. Assignments were made over the telephone by the coordinating center after eligibility had been verified; patients' treatment assignments could not be concealed, but aggregate outcome data were not revealed to patients and investigators during the study.

In the immediate-repair group, standard open repair with interposition of a synthetic graft was to be performed within six weeks after randomization. In the surveillance group, patients were followed without repair until the aneurysm reached at least 5.5 cm in diameter or enlarged by at least 0.7 cm in six months or at least 1.0 cm in one year, or until symptoms developed that were attributed to the aneurysm by the attending vascular surgeon. When one of these criteria was met, open repair was to be carried out within six weeks if the patient remained a candidate for surgery. Clinicians at the participating centers used their usual methods for preoperative evaluation, perioperative management, and the performance of surgery. All patients were to have follow-up visits every six months throughout the study. Patients in the surveillance group who had unrepaired aneurysms underwent ultrasonography or CT at these visits.

### Imaging

CT measurements were used to determine the diameter of the aneurysm for the purpose of randomization or for assessment of the need for elective repair in patients in the surveillance group. Ultrasonography was used for most follow-up imaging in patients in the surveillance group so that exposure to radiation would be minimized. Once the diameter of an aneurysm had been measured as 5.3 cm or greater, CT was used for subsequent follow-up imaging. We also attempted to obtain CT scans for all surviving patients at the end of the study.

The diameter of the aneurysm was defined as the maximal external cross-sectional measurement in any plane but perpendicular

to any bend in the vessel. CT scans obtained to determine the diameter of the aneurysm for enrollment purposes or to assess the need for repair in patients in the surveillance group were read at a central laboratory by an experienced CT radiologist. Measurements were made on hard copies of CT scans by interpolation from the display scale with the use of calipers and a magnifying glass. The variability in measurements determined by the same reader in the central laboratory was 0.2 cm or less in 63 of 70 cases studied.<sup>15</sup> The measurements of abdominal aortic aneurysms that were determined by the central laboratory averaged 0.1 cm larger than local readings of CT scans, probably because the central laboratory searched more meticulously for the maximal diameter.<sup>15</sup>

### Outcomes

The primary outcome measure was the rate of death from any cause. The secondary outcome was the rate of death related to abdominal aortic aneurysm, defined as death caused directly or indirectly by rupture or repair, preoperative evaluation, late graft failure or complication, or abdominal aortic aneurysm or pseudoaneurysm after grafting or any death occurring within 30 days after aneurysm repair (including reoperations) or within 30 days after randomization in patients in the surveillance group (none of which occurred). We attempted to obtain autopsies whenever possible, particularly in the case of unexplained deaths. An outcomes committee that was blinded to the treatment-group assignment determined the cause of death and whether the death was related to the abdominal aortic aneurysm. An independent monitoring board analyzed the study events at six-month intervals with the use of a group sequential stopping boundary.<sup>16</sup>

### Statistical Analysis

The study began in 1992 with a planned enrollment of 1350 patients over a period of four years and an additional three years of follow-up; it was calculated that this sample would provide 85 percent power to detect a 25 percent difference in mortality rates at a two-tailed significance level of 0.05, assuming an annual mortality rate of 8 percent with the inferior strategy. Because enrollment progressed more slowly than expected and fewer deaths occurred than anticipated, an additional year of enrollment and follow-up were added.

Patients were not excluded after randomization, and the primary analysis was conducted according to the intention-to-treat principle. Cumulative survival curves were generated by the product-limit method, and differences between the treatment groups were evaluated by the log-rank test. Estimates of relative risk (expressed as the risk in the immediate-repair group as compared with that in the surveillance group) and 95 percent confidence intervals were calculated with the use of the Cox proportional-hazards model. P values are two-tailed and were obtained with chi-square tests or t-tests. All data were entered twice and checked by computer algorithms.

## RESULTS

### Study Patients

Ultrasonography was performed on 126,196 veterans in the study screening program,<sup>14</sup> of whom 2662 had abdominal aortic aneurysms and were considered for randomization. With the addition of referred patients, a total of 5038 patients with aneurysms were considered for randomization, of whom 1466 (29 percent) declined to undergo evaluation, 2311 (46 percent) were excluded, 125 (2 percent) were evaluated and found eligible but declined to undergo randomization, and 1136 (23 percent) underwent randomization. The principal reasons for exclusion were an an-

aneurysm diameter outside of the eligible range (as measured on a CT scan by the central laboratory), severe heart or lung disease, and a judgment that the patient was unlikely to adhere to the protocol. Only one patient was excluded because of a rapid rate of expansion of the aneurysm.

Base-line characteristics of the patients are summarized in Table 1. Most patients were male, white, and had smoked — characteristics that reflect the demographic characteristics of the population of veterans and represent known risk factors for abdominal aortic aneurysm.<sup>13,14</sup> The two groups did not differ significantly at base line, except for a small difference in the serum creatinine level.

**Follow-up and Repair**

The mean duration of follow-up was 4.9 years. In the immediate-repair group, 92.6 percent underwent

aneurysm repair; 72.1 percent of these repairs were performed by six weeks after randomization, as specified in the protocol (Fig. 1 and Table 2). In the surveillance group, 61.6 percent had undergone repair by the end of the study; in 9.0 percent, the procedures were performed despite the fact that the aneurysms did not meet the study criteria for repair. Two patients in the immediate-repair group and one in the surveillance group underwent endovascular repair, and in one of these cases conversion to open repair was required. No patient in the surveillance group underwent repair solely because of a rapid rate of expansion of the aneurysm. As expected, the rate of repairs among the patients in the surveillance group increased with the diameter of the aneurysm at randomization. Four years after randomization, 27 percent of aneurysms that had measured 4.0 to 4.4 cm at randomization had been repaired, as compared with 53 percent of those that had measured 4.5 to 4.9 cm and 81 percent of those that had measured 5.0 to 5.4 cm. The proportion of follow-up visits completed was 85.3 percent in the immediate-repair group and 87.0 percent in the surveillance group (P=0.02).

**Mortality**

Vital status and aneurysm-repair status were known for all patients at the end of the study on July 31, 2000. There was no significant difference between the two

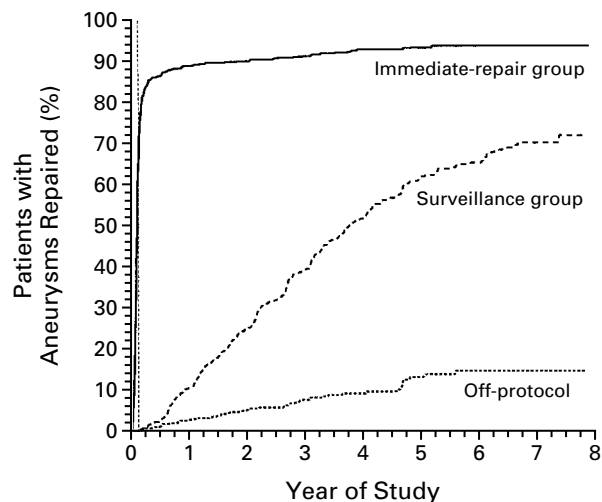
**TABLE 1. CHARACTERISTICS OF THE PATIENTS AT THE TIME OF RANDOMIZATION.\***

CHARACTERISTIC	IMMEDIATE-REPAIR GROUP (N=569)	SURVEILLANCE GROUP (N=567)
Age (yr)	68.4±5.9	67.8±6.1
Male sex (%)	98.8	99.6
White race (%)	94.6	93.5
Weight (kg)	86.9±14.4	86.7±14.5
Smoking (%)		
Ever smoked†	94.2	94.2
Current smoking	41.4	36.9
Medical conditions (%)		
Coronary disease	43.6	40.2
Cerebrovascular disease	12.0	12.7
Hypertension	57.8	54.9
Diabetes	9.7	9.9
Chronic obstructive lung disease	23.0	21.2
Use of a beta-blocker	16.9	14.8
Blood pressure (mm Hg)		
Systolic	140.1±18.0	139.7±17.4
Diastolic	79.5±10.9	79.2±10.0
FEV <sub>1</sub> (liters)	2.5±0.6	2.6±0.6
Serum creatinine (mg/dl)‡	1.2±0.3	1.1±0.3
Cholesterol (mg/dl)		
Total	212.8±39.8	212.5±40.4
LDL	138.2±37.1	137.1±34.8
HDL	39.1±13.5	40.2±21.8
Abdominal aortic aneurysm		
Diameter (cm)	4.7±0.4	4.7±0.4
Family history (%)	14.2	11.5

\*Plus-minus values are means ±SD. All differences between the groups were nonsignificant unless otherwise indicated. FEV<sub>1</sub> denotes the forced expiratory volume in one second, LDL low-density lipoprotein, and HDL high-density lipoprotein.

†Ever smoked is defined as having smoked more than 100 cigarettes over the patient's lifetime.

‡P=0.02 for the comparison between groups.



**Figure 1. Cumulative Rate of Repair of Abdominal Aortic Aneurysm, According to Treatment Group.**

Data for patients who died were not censored; the percentages are of the original cohorts. "Off-protocol" repairs are those of aneurysms that did not meet the study criteria for repair in patients in the surveillance group. The vertical dashed line at six weeks represents the protocol deadline for repair in the immediate-repair group.

TABLE 2. OUTCOMES AMONG PATIENTS WITH ABDOMINAL AORTIC ANEURYSM.\*

VARIABLE	IMMEDIATE-REPAIR GROUP (N=569)	SURVEILLANCE GROUP (N=567)	RELATIVE RISK (95% CI)
Death			
Total — no. (%)	143 (25.1)	122 (21.5)	1.21 (0.95–1.54)†
According to diameter of aneurysm — no./no. in subgroup (%)			
4.0–4.4 cm	37/174 (21.3)	32/197 (16.2)	1.48 (0.92–2.38)
4.5–4.9 cm	46/205 (22.4)	33/188 (17.6)	1.27 (0.81–1.99)
5.0–5.4 cm	60/190 (31.6)	57/182 (31.3)	1.02 (0.71–1.47)
According to age — no./no. in subgroup (%)			
50–59 yr	8/47 (17.0)	8/51 (15.7)	1.02 (0.38–2.73)
60–69 yr	61/251 (24.3)	55/279 (19.7)	1.34 (0.93–1.93)
70–79 yr	74/271 (27.3)	59/237 (24.9)	1.10 (0.78–1.55)
AAA-related — no. (%)	17 (3.0)	15 (2.6)	1.15 (0.58–2.31)
Thoracic aortic aneurysm-related — no. (%)	2 (0.4)	0	
Other sudden death — no. (%)	23 (4.0)	24 (4.2)	1.00 (0.56–1.77)
Rupture of AAA — no. (%)	2 (0.4)	11 (1.9)	
Repair of AAA (ruptured and unruptured) — no. (%)	527 (92.6)	349 (61.6)	
Other AAA-related hospitalization — no. of hospitalizations‡	255	129	
Status of surviving patients at end of study			
Unrepaired AAA — no. (%)	31 (5.4)	155 (27.3)	
Repaired AAA			
Exit CT performed — no. (%)	328 (57.6)	242 (42.7)	
Proximal AAA ≥4.0 cm — no.	19 (3.3)	17 (3.0)	
Iliac-artery aneurysm ≥2.5 cm — no.	27 (4.7)	13 (2.3)	
Any aneurysm — no. (%)§	77 (13.5)	185 (32.6)	
No CT available — no. (%)	67 (11.8)	48 (8.5)	

\*CI denotes confidence interval, AAA abdominal aortic aneurysm, and CT computed tomography.

†After adjustment for clinical characteristics at the time of randomization that were significant independent predictors of death according to forward stepwise regression analysis, the relative risk of death was 1.15 (95 percent confidence interval, 0.90 to 1.47). The significant independent predictors of death (in decreasing order of the variance they explained) were a higher serum creatinine level, a lower weight, a diagnosis of chronic obstructive lung disease, a larger AAA diameter, a lower forced expiratory volume in one second, a diagnosis of diabetes, and nonuse of a beta-blocker.

‡Data include hospitalizations for complications of AAA repair shown in Table 3.

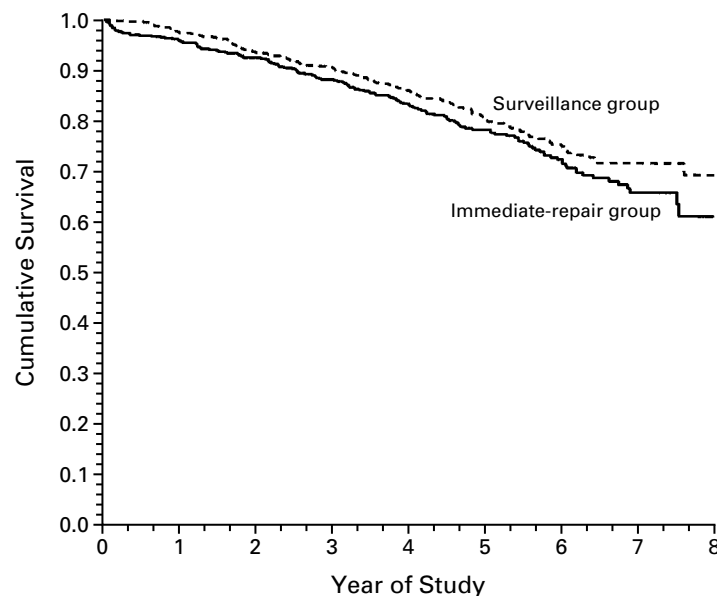
§Data are for unrepaired aneurysms and clinically important residual or recurrent aneurysms after repair.

groups in the primary outcome of the rate of death from any cause (relative risk, 1.21 for repair vs. surveillance; 95 percent confidence interval, 0.95 to 1.54) (Fig. 2 and Table 2). Survival trends did not favor immediate repair in any of the prespecified subgroups defined according to age or diameter of aneurysm at randomization, and there was no significant interaction with respect to mortality between treatment group and either age or diameter of aneurysm at randomization. The results were similar after adjustment for base-line clinical variables that were significant independent predictors of death (adjusted relative risk, 1.15; 95 percent confidence interval, 0.90 to 1.47) (Table 2).

#### Rupture of Aneurysms

The rate of death related to abdominal aortic aneurysm was not reduced by immediate repair (Table 2).

Eleven ruptures of abdominal aortic aneurysms occurred in the surveillance group, a rate of 0.6 percent per year of follow-up of unrepaired aneurysms. Of these ruptures, two were incidental findings at the time of elective repair (one described as a hole in the aortic wall covered by a thin layer of connective tissue, the other as a hole plugged by thrombus), and seven resulted in death. Nine of the 11 diagnoses of rupture were confirmed at the time of surgery, another had a characteristic clinical presentation and was associated with findings on CT scanning after embalming that were consistent with rupture, and the last had only a characteristic clinical presentation. The two patients in the immediate-repair group who had ruptures of abdominal aortic aneurysms included one with an incidental rupture (also described as a hole in the aortic wall covered by a thin layer of connective tissue) detected at the time of elective repair and one who died



No. AT Risk								
Surveillance	567	552	530	513	393	274	183	76
Immediate repair	569	545	526	502	383	264	172	67

Figure 2. Cumulative Survival According to Treatment Group.

after the repair of a contained rupture proximal to a previous repair. Thoracic aortic aneurysm caused two deaths in the immediate-repair group, one from the rupture of a thoracic aneurysm after the repair of an abdominal aortic aneurysm and the other after elective repair of a thoracic aneurysm. In addition to operative deaths and those caused by rupture, there were 24 sudden deaths in the surveillance group and 23 in the immediate-repair group, suggesting that there was not a large number of undiagnosed ruptures of aneurysms in the surveillance group. In addition to those listed in Table 2, two other deaths in the immediate-repair group could be considered to be aneurysm-related: a sudden death at home two months after an aneurysm repair that was complicated by postoperative ventricular tachycardia and a death following repair of a ventral hernia resulting from aneurysm repair.

In 20 patients in the surveillance group, repair was performed because of pain suggestive of rupture but no rupture was found at the time of surgery (a presentation known to herald imminent rupture<sup>17</sup>). Although these aneurysms were repaired because of pain, 10 of them were measured on CT scans by the central laboratory as 5.5 cm or more in diameter, and another 6 were measured as that large by the local laboratory but the CT scans had not been read centrally at the

time of surgery. Three other patients in the surveillance group had incidental repair of an aneurysm during aortoiliac surgery for symptomatic occlusive disease (resulting in one of the operative deaths); in two of these patients, the diameter of the aneurysm had been measured by the local laboratory as 5.5 cm or greater before surgery, but there was no reading from the central laboratory before surgery.

#### Enlargement of Aneurysms

The median rate of increase in the diameter of aneurysms in the surveillance group, according to the first and last CT readings by the central laboratory (or the first and last ultrasonographic readings in patients with fewer than two CT readings by the central laboratory), was 0.32 cm per year (interquartile range, 0.16 to 0.42 cm; mean follow-up time, 3.0 years). The only significant univariate predictors of an increased rate of enlargement were a larger initial diameter and the absence of diabetes.

#### Complications of Repair

The operative mortality associated with the repair of unruptured abdominal aortic aneurysms was 2.0 percent at 30 days; when in-hospital mortality beyond 30 days was included, the rate was 2.4 percent. An additional 1.5 percent of the patients required reoper-

ation because of complications. The results of repair of unruptured abdominal aortic aneurysms according to treatment group are presented in Table 3. The operative mortality and the rate of reoperation were not higher in the surveillance group, but there were more myocardial infarctions. In two patients in the immediate-repair group, laparotomy was performed, but the first attempt at repair of the aneurysm was aborted, and the surgery had to be completed at a later date; in two patients in the surveillance group, laparotomy was performed, but the repair of the aneurysm was aborted because metastatic cancer was found.

As expected, given the greater number of repairs of abdominal aortic aneurysms performed in the immediate-repair group, there were also more rehospitalizations because of postoperative complications (Table 3). The total number of hospitalizations related to abdominal aortic aneurysms (both for repair and for other reasons including preoperative evaluation, canceled repairs, postoperative complications, and ruptures without repair) was 39 percent lower in the surveillance group than in the immediate-repair group (Table 2).

The number of patients surviving with aneurysms at the end of the study is also shown in Table 2. These data include patients with unrepaired abdominal aortic

aneurysms and those with clinically important residual or recurrent aneurysms after repair (defined as an abdominal aortic aneurysm of at least 4.0 cm in diameter proximal to the graft or an iliac-artery aneurysm of at least 2.5 cm in diameter).

## DISCUSSION

As compared with surveillance by CT or ultrasonography, a strategy of immediate repair did not improve the rate of survival among patients with low surgical risk who had abdominal aortic aneurysms of 4.0 to 5.4 cm in diameter. The confidence interval excludes a benefit of more than 5 percent from immediate repair. These findings were obtained despite a low operative mortality rate. The nonsignificant survival trends did not favor immediate repair in any of the pre-specified subgroups defined according to age or diameter of aneurysm at entry.

We did not find an increase in operative mortality or the need for reoperation when elective repair was delayed until the diameter of the aneurysm was 5.5 cm, as had been previously predicted,<sup>18</sup> but more myocardial infarctions occurred. The low mortality associated with repair of unruptured aneurysms in our study may be attributed both to the skill of the surgical teams and to our criteria for inclusion, which selected for patients who did not have high surgical risk and were therefore presumably most likely to benefit from elective repair.

Our results confirm and extend those of the only other randomized trial of surgery for small abdominal aortic aneurysms, the United Kingdom Small Aneurysm Trial, which also found no benefit from repair of aneurysms less than 5.5 cm in diameter.<sup>19</sup> The confidence intervals in that study did not exclude a 25 percent reduction in mortality with immediate repair, and the operative mortality in the immediate-repair group in that study was a relatively high 5.8 percent. These factors left some experts unconvinced of the conclusions drawn by the study investigators, and several subsequent editorials endorsed immediate repair of abdominal aortic aneurysms smaller than 5.5 cm if the operative mortality was likely to be less than 5.8 percent.<sup>20,21</sup> Our findings indicate that there is unlikely to be a survival benefit associated with the elective repair of abdominal aortic aneurysms smaller than 5.5 cm, even when there is low mortality associated with the procedure.

The most likely reason that immediate repair was not beneficial in our study was that the rate of rupture was low (0.6 percent per year). This rate of rupture, although consistent with those reported in previous population-based studies,<sup>5,6</sup> was obtained with the aid of an active surveillance program in which patients were urged to return for scheduled imaging studies at six-month intervals. Whether the results of

**TABLE 3.** COMPLICATIONS OF REPAIR OF UNRUPTURED ABDOMINAL AORTIC ANEURYSMS.\*

VARIABLE	IMMEDIATE- REPAIR GROUP (N=526)	SURVEILLANCE GROUP (N=340)
	no. (%)	
Operative death		
Within 30 days	11 (2.1)	6 (1.8)
Within 30 days or during hospitalization	14 (2.7)	7 (2.1)
Major complication with no operative death		
Reoperation required	9 (1.7)	4 (1.2)
Myocardial infarction†	5 (1.0)	13 (3.8)
Amputation	2 (0.4)	2 (0.6)
Paraplegia	0	2 (0.6)
Stroke	3 (0.6)	2 (0.6)
Pulmonary embolism	4 (0.8)	1 (0.3)
Dialysis	1 (0.2)	2 (0.6)
Any complication‡	275 (52.3)	193 (56.8)
Late graft failure§	2 (0.4)	1 (0.3)
Rehospitalization for complications	108 (20.5)	56 (16.5)

\*Differences between groups were not significant unless otherwise indicated.

†P=0.004 for the comparison between groups.

‡Complications have been described elsewhere.<sup>12</sup>

§All three late graft failures were fatal aortoenteric fistulas.

our trial would apply to practice settings with less rigorous surveillance programs is not known. Our finding that diabetes was associated with slower enlargement of aneurysms is consistent with our previous observation that diabetes is associated with a reduced prevalence of aneurysm,<sup>13,14</sup> but the reasons for this association remain unknown.

A limitation of our study is that the subjects were almost all men. Although this imbalance reflects the predominance of men among veterans, it also reflects the demographic characteristics of persons with abdominal aortic aneurysm, which is four times as prevalent in men as in women.<sup>22</sup> Women accounted for only 17 percent of the study population in the United Kingdom Small Aneurysm Trial, which was conducted in a general population. As compared with men, women with abdominal aortic aneurysm are older and appear to have a higher risk of rupture,<sup>23</sup> higher rupture-related mortality,<sup>24</sup> and higher mortality after elective repair,<sup>25,26</sup> so the results of these trials may not be applicable to women.

Another limitation of our study is the duration of follow-up. The larger number of aneurysms that remained unrepaired in the patients in the surveillance group at the end of the study could ultimately lead to increased mortality, but no trend in this direction has yet been observed.

The question raised at the end of the report of the United Kingdom Small Aneurysm Trial<sup>19</sup> regarding whether the optimal diameter for repair might be greater than 5.5 cm was not addressed by either that trial or our own. However, in the surveillance groups in both trials, death resulted from repair of nonruptured aneurysms as frequently as from rupture of aneurysms (18 vs. 17 in the United Kingdom study and 7 vs. 7 in our study). Ideally, future trials should be conducted comparing immediate repair with surveillance in patients with larger aneurysms, but the feasibility of such an approach is questionable because physicians and patients are reluctant to defer repair further and because a limited number of patients with larger aneurysms would be available for enrollment (for example, of the abdominal aneurysms that are at least 4.0 cm in diameter when detected at screening, only one fifth are 5.5 cm or larger<sup>14</sup>). Our findings support a policy of reserving elective repair for abdominal aortic aneurysms at least 5.5 cm in diameter.

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## APPENDIX

The Aneurysm Detection and Management (ADAM) Veterans Affairs Cooperative Study Group also includes the following: *Investigators at Veterans Affairs Medical Centers* — G.B. Zelenock, C. Shanley, C. Sekerak, M. Ligg, L. Trohallis (Ann Arbor, Mich.); A.W. Averbook, C.L. Mesh, K. Kaelin, T. O'Malley, E. Wingard, J. Lindesmith, J. Francosky (Cleveland); A. Furst, M. Tabbara, A.A. Nunez, G. Paperwalla, K. Nunez, C. Estep, J. Taylor

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