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Fit patients with small abdominal aortic aneurysms (AAAs) do not benefit from early intervention

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Objectives: **The UK Small Aneurysm Trial (UKSAT) and the American Aneurysm Detection and Management (ADAM) trial both concluded that early elective open surgery does not confer any late survival advantage in patients with small abdominal aortic aneurysm (AAA) with diameter 4.0 to 5.5 cm. However, two trials of endovascular aneurysm repair in small AAA have started based upon speculation that a sub-group of particularly fit patients, with low operative mortality, may benefit from early intervention. Here we investigate whether the fittest patients from the UKSAT might have benefited from early intervention.**
Methods: **A total of 1090 patients randomized into the UKSAT between 1991 and 1995 were followed for an average of 12 years for mortality. Baseline data were used to calculate the Customized Probability Index (CPI), a validated prognostic risk score for operative mortality after elective open aneurysm repair that assigns risk points for history of cardiac, pulmonary, and renal disease and subtracts risk points for use of statins and beta-blockers. Cox regression was used to assess any differences in all-cause or aneurysm-related mortality between policies of early surgery or surveillance across the fitness spectrum. Tests for interaction used CPI scores as a continuous variable but patients also were stratified into tertile groups for descriptive purposes. Hazard ratios were adjusted for age, gender, and aneurysm diameter.**
Results: **A total of 714 deaths (95 aneurysm-related) occurred in 8485 person-years (number of patients multiplied by average years of conditional follow-up). The mean (standard deviation [SD]) CPI score was 8.1 (9.9) with similar scores between randomized groups. The tertile groups had mean (SD) scores of −1.8 (3.7) for the 389 fittest patients, 8.8 (3.3) for the 438 moderately fit, 21.4 (6.6) for the 261 least fit with missing scores in 2 patients. The tests for interaction were non-significant for both all-cause (P = .176) and aneurysm-related mortality (.178). However, for the least fit patients a survival advantage was seen in the early surgery group; adjusted hazard ratios 0.73 (95% confidence interval [CI] 0.56-0.96) and 0.46 (95% CI 0.22-0.98) for all-cause and aneurysm-related mortality respectively.**
Conclusion: **Early elective surgery did not confer any survival benefit in the fittest patients. On the contrary, the possibility of a survival benefit from early intervention in patients of poor fitness merits further investigation through meta-analysis or validation in other prospective studies. (J Vasc Surg 2008;48:1375-81.)**

The UKSAT and the American Aneurysm Detection and Management (ADAM) trial both concluded that early elective open surgery was not justified in patients with small abdominal aortic aneurysm (AAA) as regular ultrasound scan surveillance according to a protocol where surgery was considered if the aneurysm reached 5.5 cm, grew fast, or became tender was equally safe and incurred less costs.[1-4] These trials demonstrated a 30-day operative mortality for elective open repair ranging from 2.7% in the USA up to 5.5% in the UK and both indicated that the rupture rate of small AAA was very low, less than 1% per annum. Nevertheless, two new randomized trials, namely the Comparison of surveillance vs Aortic Endografting for Small Aneurysm Repair (CAESAR) trial based predominantly in Europe[5] and the Medtronic PIVOTAL trial in the USA,[6] have been instigated to investigate whether endovascular aneurysm repair (EVAR) might be justified in patients with small aneurysms measuring between 4.0 and 5.5 cm. The investigators for both trials argue that if the 30-day mortality after EVAR in small AAA was very low, about 1% or less, then early EVAR intervention may be justified in patients with small AAA. In addition, the investigators cite evidence from EUROSTAR (collected by 56 institutions in a multicentre data registry) data that patients with smaller aneurysms tend to fare better than those with larger aneurysms following EVAR in terms of long-term mortality and graft complication rates.[7]

However, patient fitness also influences operative mortality and there has been much speculation on the interaction between age or fitness and the decision on whether to intervene for AAA.[8,9] Furthermore, guidelines from the USA have advised that aneurysm repair may be justified in a subgroup of young and fit patients with small aneurysms.[10] For large aneurysms, analysis of data from EVAR trial 1 shows that the fittest group of patients may experience the greatest benefit of EVAR over open repair in terms of 30-day operative mortality.[11] These findings, echoed in the Dutch Randomized Endovascular Aneurysm Management (DREAM) trial,[12] have

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revealed rather counter-intuitive evidence about the role of patient fitness in the management of AAA.

Investigations in the UKSAT dataset as to whether the benefit of a policy of early surgery varied by age, gender, and initial aneurysm diameter (interaction analyses *P* values .152, .756, and .471, respectively) have not demonstrated any significant findings.[4] However, we return to the UKSAT data to examine directly whether there was any interaction between fitness and randomized group, and whether there exists a sub-group of patients with such low operative mortality that early intervention using open surgery is justified. After consideration of other validated prognostic fitness scores, we decided to use the Customized Probability Index (CPI) as the marker of patient fitness,[13,14] consistent with our use of the CPI in the assessment of how fitness impacts on the outcome of endovascular repair of large aneurysms.[11]

PATIENTS AND METHODS

Patients. The design and methods for the UK Small Aneurysm trial have been described previously.[15] In summary, patients of both genders aged between 60 and 76 years with an AAA measuring between 4.0 and 5.5 cm in the anterior-posterior plane on ultrasound scan and considered fit for open surgical repair were offered entry into the trial. Fitness for open surgery was evaluated locally, key markers of cardiac, pulmonary, and renal fitness monitored, but poor life expectancy was not a formal exclusion criterion. Between 1991 and 1995, a total of 1090 patients were randomized to either immediate surgery (n = 563) or regular ultrasound scan surveillance until the aneurysm grew fast (>1.0 cm/year), became tender, or grew to 5.5 cm when surgery was considered (n = 527). Patients were followed-up by trained coordinators until November 1998, after which time local records were reviewed for occurrence of aortic repair. All patients were followed-up for death through the UK Office for National Statistics (ONS), until November 30, 2005, (minimum follow-up 10 years, mean 12.2 years). Patients who were lost to follow-up at the ONS were censored at the last date seen by the local trial coordinator. An endpoints committee reviewed the causes of death. Aneurysm-related deaths were defined as death from any cause within 30 days of elective AAA repair or death at any time with the underlying cause of death coded as ICD9 441.3 (rupture) or 441.4 (unruptured).

Fitness scoring. The CPI was used to ascribe fitness status at baseline for all the patients randomized into the trial.[13,14] We had previously considered other validated prognostic scores; the Revised Lee Goldman Index is not reliable for AAA surgery,[16] the Leiden Score only identifies low-risk patients[17] and the Glasgow Aneurysm Score does not contain a pulmonary component.[18] The CPI has been validated for all vascular surgery patients, is simple to calculate, and includes components for the three most commonly cited factors associated with outcome after AAA repair, namely cardiac, respiratory, and renal function. The electrocardiograms (ECGs) were reported by two independent trained observers.[1] Fig 1 describes the method of calculating the CPI. Some data for this calculation were missing in 32 patients (20 in the surgery group and 12 in the surveillance group). The CPI scores were imputed for 30 of these patients where only one component was missing (using linear regression analysis to impute that component based on patients without any missing data), but 2 patients in the surveillance group had more than one missing component and were not included in the analysis.

Presence of cardiovascular morbidity	
Ischaemic heart disease (IHD)	+13 points
Defined as:	
previous history of ICD9 codes 410, 411, 412, 413, 414 (apart from 414.1)	
or previous history of Coronary Artery Bypass Graft (CABG)	
or probable ischaemia on ECG	
or positive Rose Questionnaire with possible ischaemia on ECG	
Congestive cardiac failure	+14 points
Defined as:	
previous history of all 428 ICD9 codes	
History of cerebrovascular event	+10 points
Defined as:	
previous history of ICD9 codes 430-437	
Hypertension	+7 points
Defined as:	
previous history of ICD9 code 401	
or hypertension treatment	
Renal dysfunction	+16 points
Defined as:	
Previous history of ICD9 codes 584-586 for chronic or acute renal failure	
or serum creatinine ≥180μmol/L	
or serum urea >11mmol/L	
Chronic pulmonary disease	+7 points
Defined as:	
ratio of observed to expected FEV_1 ≤60%	
Beta-blocker use	-15 points
Based on baseline medication	
Statin use	-10 points
Based on baseline medication	

ICD9: International Classification of Diseases 9th Revision
FEV_1: Forced Expiration Volume in 1 second

Fig 1. Method of calculation for Customized Probability Index (CPI).

Statistical analysis. A statistical plan was agreed on before the data were analyzed. Cox regression was used to analyze all-cause and aneurysm-related mortality (censoring other causes of death) for all patients within their randomized groups (intention-to-treat). Whether the benefit of early surgery varied according to fitness level was assessed by including an interaction term between randomized group and fitness score as a continuous variable. Crude hazard ratios were calculated as well as ones adjusted for age, gender, and aneurysm diameter at randomization. For presentation purposes, data were divided into tertile groups of fitness such that approximately equal numbers fell into the three groups. Kaplan-Meier estimates were used to determine survival at 12 years. The results presented here are based upon analysis of the same dataset that was used for the 12-year overall mortality results of the UKSAT.[4] However, there are some very slight differences in hazard ratios and classification of causes of death. These can be explained by a different set of adjustment variables in the Cox models and also a different classification of aneurysm-related death. In the 12-year overall mortality paper, deaths from elective AAA repair were combined with deaths from AAA rupture (89 events in total), but for this analysis a formal description of aneurysm-related death was defined for patients whose underlying cause of death on the death certificate was

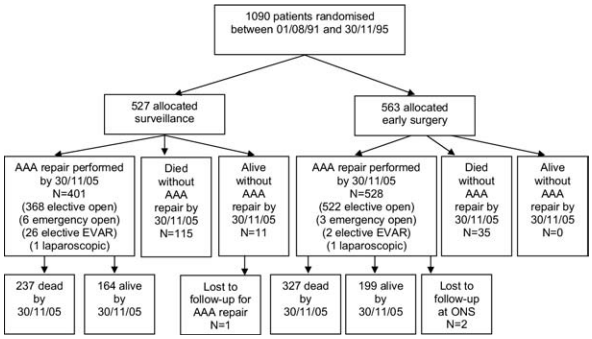

Fig 2. CONSORT diagram showing flow of patients through the UK Small Aneurysm Trial up to 30th November 2005.

classified under ICD9 codes 441.3 or 441.4, and this detected an additional six aneurysm-related deaths.

RESULTS

Summary of patients and AAA repairs. Fig 2 shows patient flow through the trial up to November 30, 2005. The mean (SD) age of all 1090 patients at baseline was 69.3 (4.4) years and 902 (83%) were male. The mean (SD) AAA diameter was 4.6 (0.4) cm in both randomized groups. There were 2 patients lost to follow-up for mortality (both already had undergone aneurysm repair) and these were censored at the date last known to be alive. There were a further 5 patients (4 of whom were dead) where the repair status of their aneurysm was unknown and we assumed that no aneurysm repair was performed prior to death or censoring. The 1 patient who was still thought to be alive without aneurysm repair was censored at the date last seen by the coordinator without aneurysm repair. This generated 8485 person-years of follow-up. During this period, 929 patients underwent aneurysm repair, 899 by open method, 28 by EVAR, and 2 by laparoscopic repair. There were 58 deaths within 30 days of repair generating an overall post-operative mortality rate of 6.2% (95% confidence interval [CI] 4.8 to 8.0). There were nine emergency repairs, 7 of whom died within 30 days of their operation. Thus, 30-day mortality for elective AAA repair was 5.5% (95% CI 4.2 to 7.2).

Summary of fitness scores. The distribution of CPI scores is shown in Fig 3. The surgery group had a mean (SD) score of 8.0 (9.8) and a total range of −15 to 46. The surveillance group had a mean (SD) score of 8.2 (9.9) and a total range of −15 to 43. The patients were split into the tertile groups of fitness as shown in Fig 3 (this classification provided the most similar tertile sizes). The proportion of patients having elective AAA repair decreased as fitness deteriorated across the fitness tertiles; for the early surgery group 97%, 93%, and 91% had elective surgery in the good, moderate, and poor groups, respectively; for the surveillance group 82%, 79%, and 64% had elective surgery in the good, moderate, and poor groups, respectively. These proportions are based upon numbers having surgery during an average of 12 years follow-up and, therefore, part of the difference in proportions between randomized groups is explained by the mortality attrition occuring during follow-up.

Results for operative mortality of patients in the early surgery group having their AAA repair within 6 months of surgery is shown in Table I – Appendix (online only) which compares the predicitive ability of the CPI with the Glasgow Aneurysm Score (GAS).

All-cause mortality. A total of 714 deaths occurred, 362 in the surgery group and 352 in the surveillance group (Table I). Adjusted hazard ratios indicated a marginal, but non-significant benefit in favor of the surgery group in terms of all-cause mortality; 0.88 (95% CI 0.76-1.02). The Kaplan-Meier survival estimates at 12 years were 36% (95% CI 32-40) in the surgery group and 33% (95% CI 28-37) in the surveillance group.

AAA-related mortality. A total of 95 AAA-related deaths occurred, 42 in the surgery group and 53 in the surveillance group (Table II). Adjusted hazard ratios also indicated a marginal, but non-significant benefit in favor of the surgery group in terms of AAA-related mortality; 0.74 (95% CI 0.49-1.10). The Kaplan-Meier estimates for survival without AAA-related death at 12 years were 92% (95% CI 89-94) in the surgery group and 88% (95% CI 84-90) in the surveillance group.

Results for interaction between randomized group and CPI fitness score. Tables I and II show the results of Cox regression analyses for all-cause and aneurysm-related mortality by randomized group. For both randomized groups, mortality appeared to increase as patient fitness deteriorated with a mortality rate of 6.3 per 100 person-years in the fittest group compared with a rate of 14.2 in the least fit group. However, there was no strong evidence to indicate that hazard ratios between randomized groups varied across the fitness spectrum with *P* values of .176 and .178 for all-cause and aneurysm-related mortality, respectively. An unexpected finding was noted in the least fit group of patients where a significant benefit was seen under a policy of early surgery rather than surveillance. This was particularly marked in terms of aneurysm-related mortality, which was halved; adjusted hazard ratio 0.46 (95% CI 0.22-0.98). A post-hoc analysis was performed to investigate whether this benefit could be explained by any other potentially important confounders. Thus, the adjusted Cox regression hazard ratios for patients in the tertile of worst fitness in Tables I and II were further adjusted for Forced Expiration Volume in 1 second (FEV_1), smoking status, aspirin use, cholesterol, log (creatinine), presence of cardiac disease, and systolic blood pressure. The hazard ratios (HRs) did not alter markedly; all-cause mortality HR = 0.69 (95% CI 0.51-0.94), AAA-related mortality HR = 0.46 (95% CI 0.20-1.07).

Causes of death for all patients are shown in Table III. There were nine cases of emergency AAA repair (Fig 2) but only 2 patients in the surveillance group survived the procedure beyond 30-days or discharge. Of the 115 and 35 patients dying without AAA repair in the surveillance and surgery groups, respectively, (Fig 2), 19/115 (17%) and 8/35 (23%) died of ruptured AAA. The remaining patients

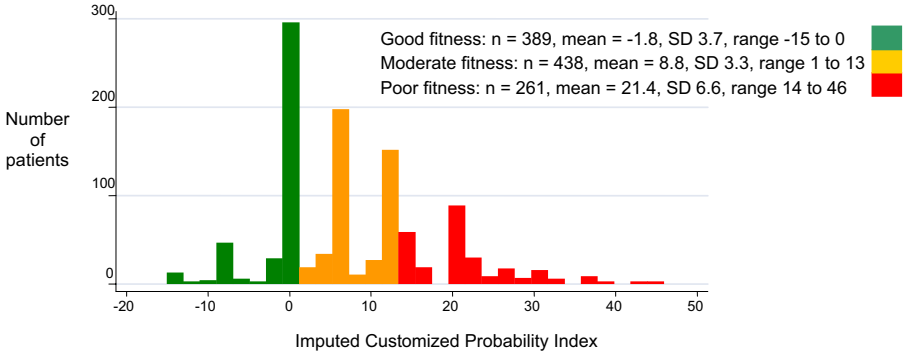

Fig 3. Customized Probability Index (CPI) fitness scores split into tertiles of fitness.

Table I. Deaths from any cause by randomized group with crude and adjusted Cox regression hazard ratios and test for interaction between fitness score and randomized group

	No. deaths/No. patients (deaths per 100 person.years)		*Crude hazard ratio (95% CI) [P value]*	*Adjusted* hazard ratio (95% CI) [P value]*	*P value for interaction test for adjusted model*
	Surgery n = 563	*Surveillance n = 527*	*n = 1090*	*n = 1090*	*N = 1088*
All patients	362/563 (8.0)	352/527 (8.8)	0.89 (0.77-1.04) [.134]	0.88 (0.76-1.02) [.095]	
By fitness tertiles					
Good fitness n = 389	108/204 (6.1)	106/185 (6.5)	0.92 (0.70-1.20) [.540]	0.92 (0.70-1.20) [.530]	
Moderate fitness n = 438	153/232 (8.0)	126/206 (7.8)	1.00 (0.79-1.26) [.986]	0.99 (0.78-1.25) [.920]	.176 (fitness score used as a continuous variable)
Poor fitness n = 261	101/127 (12.5)	118/134 (15.9)	0.75 (0.57-0.98) [.037]	0.73 (0.56-0.96) [.025]	
Missing fitness data n = 2	0/0	2/2	—	—	

No., Number; *CI*, confidence interval; *AAA*, abdominal aortic aneurysm; *n*, number.
*Adjustment made for age, gender, and initial AAA diameter.

died of causes unrelated to their aneurysm, principally other forms of cardiovascular disease and cancer, Table III.

DISCUSSION

For aneurysms, it has been suggested that the fittest group of patients benefit most from aggressive intervention: for small AAA the fittest patients should undergo early repair[8,10] and for large AAA the fittest patients should undergo open repair.[9] Moreover, in the current era of endovascular aneurysm repair, the debate about decision-making and fitness for aneurysm repair has reopened. Fitness scoring of patients with large AAA enrolled in the EVAR 1 and DREAM trials already has provided evidence against the premise that fitter patients should receive open repair, as the benefit of endovascular repair was most marked in the fittest patients.[11,12] New trials are testing whether EVAR is justified in fit patients with small AAA.[5,6] Here we add to the current debate about fitness by providing evidence against a selective policy of early open repair for the fittest patients with small aneurysms. In fact, fitness scoring of patients enrolled in the UKSAT possibly indicates the converse; the least fit patients may gain most from a policy of early elective open surgery. However, the overall tests for interaction did not provide any strong evidence that the benefit of surgery varied significantly across the whole fitness spectrum.

For the groups of good fitness and moderate fitness there was no difference in either all-cause or aneurysm-related mortality after 12 years of follow-up, as all the hazard ratios were close to 1. In contrast, in the group of least fitness, aneurysm-related mortality from a policy of surveillance was twice that from a policy of early intervention. There also appeared to be a benefit for all-cause mortality associated with a policy of early surgery in this group. Since the CPI fitness score does not directly include a component for age or gender, these were included in the adjustment variables. In fact, there was no difference in age across these tertiles, all three groups having a mean (SD) age of 69 (4) years, and thus the benefit seen in the least-fit group is unlikely to have been influenced by age.

In the UKSAT, fitness for surgery was determined locally, although guidelines were provided. Comparison of

Table II. Deaths from AAA-related cause by randomized group with crude and adjusted Cox regression hazard ratios and test for interaction between fitness score and randomized group

	No. deaths/No. patients (deaths per 100 person/years)		*Crude hazard ratio (95% CI) [P value]*	*Adjusted* hazard ratio (95% CI) [P value]*	*P value for interaction test for adjusted model*
	Surgery n = 563	*Surveillance n = 527*	*n = 1090*	*n = 1090*	*n = 1088*
All patients	42/563 (0.9)	53/527 (1.3)	0.74 (0.49-1.10) [.138]	0.74 (0.49-1.10) [.137]	
By fitness tertiles					
Good fitness n = 389	12/204 (0.7)	12/185 (0.7)	0.93 (0.42-2.07) [.861]	0.94 (0.42-2.10) [.885]	
Moderate fitness n = 438	20/232 (1.0)	17/206 (1.1)	1.04 (0.54-2.00) [.906]	1.03 (0.54-1.97) [.925]	.178 (fitness score used as a continuous variable)
Poor fitness n = 261	10/127 (1.2)	23/134 (3.1)	0.44 (0.21-0.93) [.032]	0.46 (0.22-0.98) [.043]	
Missing fitness data n = 2	0/0	1/2	—	—	

No., Number; *CI,* confidence interval; *AAA,* abdominal aortic aneurysm; *n,* number.
*Adjustment made for age, gender, and initial AAA diameter.

the UK patients with those enrolled in the ADAM trial,[3] shows that the UK trial enrolled patients of poorer fitness with, for example, worse lung and renal function. Thus, the poor fitness group defined by CPI in the UK trial may not be represented well in the ADAM trial. Some of the difference in mortality from elective open surgery between the two trials has been attributed to these differences in patient fitness.[2] The poor fitness group in the UK trial has much higher mortality rates than the good and moderate fitness groups, with rates in the poor fitness group being almost twice those in the good fitness group (Tables I and II). Therefore, it is pertinent to consider how the inclusion of this poor fitness group (i) has influenced the findings of the UKSAT, (ii) affects any future trials of endovascular repair vs surveillance for small aneurysms, and (iii) influences surveillance strategies for those of poor fitness with screen-detected small aneurysms. These issues are discussed below.

Final, 12-year follow-up of patients enrolled in the UKSAT showed no significant difference in all-cause mortality between the randomized groups, although the direction of results was in favor of early surgery. There is no evidence that the fitter patients gained any benefit from a policy of early intervention, but the inclusion of the poor fitness group may have influenced the direction of the result. Survival is important, but not the only factor used in the estimation of cost-effectiveness. Without knowledge of the costs and quality of life changes in the poor-fitness group, it is not possible to predict whether early intervention would be cost-effective in this group of patients. Aneurysm-related mortality was not specified as an outcome measure when the UKSAT was established in 1991, and initially the trial did not report on aneurysm-related mortality. Therefore, the aneurysm-related mortalities reported here may be underestimates, since we did not identify aneurysm-related deaths that may have occurred more than 30-days after surgery.

We only can speculate as to why, in the poor-fitness group, early surgery conferred a possible benefit on aneurysm-related mortality. First, factors used to define patient fitness appear to influence aneurysm rupture; for example, poor lung function is associated with an increased risk of rupture.[19] Second, any rapid deterioration of fitness may have rendered patients unsuitable for open surgery when their aneurysm exceeded the 5.5 cm threshold diameter, leading to an excess of late ruptures in the surveillance group. However, there is little evidence for this, since the proportion of ruptures in those without aneurysm repair was similar in the two randomized groups and only two cases of late rupture (2001-2006) were reported in the surveillance group. Third, it might be argued that patients of worst fitness experience more marked deterioration over time which not only increases their risk of aneurysm rupture but also makes them more vulnerable to the post-operative complications associated with their later aneurysm repair, particularly in relation to respiratory and renal function that have been shown to be strong prognostic indicators of survival after aortic repair.[6-18,20,21] However, there are too few operative deaths to evaluate whether operative mortality increased over time in the surveillance group although no significant difference was found between randomized groups overall.[4]

The criterion of fitness for surgery or intervention varies from center to center and from country to country. Individual center or national results are likely to be influenced strongly by the selection of patients, particularly with respect to their fitness. Future meta-analyses of randomized trials may have to take fitness into consideration when interpreting results. For current and future trials of either interventions or pharmacologic therapy for the management of AAA, it will be essential to collect baseline data to describe the fitness of patients and this may prove to be particularly important for the current trials testing EVAR in small AAA.[5,6] For this latter purpose, it would be beneficial

Table III. Causes of death by randomized group for all patients (A) and for subgroup dying without AAA repair (B)

Cause of death	*Surgery group*	*Surveillance group*	*Total*
(A) Causes of death by randomized group for all patients			
Myocardial infarction	55	58	113
Stroke	27	27	54
Thoracic aortic aneurysm	9	13	22
Primary AAA rupture[a]	**11**	**23**	**34**
Secondary graft rupture after AAA repair	**2**	**2**	**4**
Death attributed to elective AAA repair[b]	**29**	**28**	**57**
Other cardiovascular	72	70	142
Lung cancer	33	21	54
Other cancer	56	46	102
Other deaths	66	63	129
Unknown	2	1	3
Total	362	352	714
Total AAA-related	**42**	**53**	**95**
(B) Causes of death for all patients dying without AAA repair by randomized group			
Myocardial infarction	5	20	25
Stroke	2	12	14
Dissecting aortic aneurysm	1	3	4
Primary AAA rupture[a]	**8**	**19**	**27**
Other cardiovascular	6	23	29
Lung cancer	4	12	16
Other cancer	4	11	15
Other deaths	5	14	19
Unknown	0	1	1
Total	35	115	150

AAA, Abdominal aortic aneurysm.
[a]AAA related in bold font.
[b]Deaths within 30 days of elective repair or coded on death certificate under ICD9 414.4 as death from non-ruptured AAA.

to have international consensus about the fitness scoring system to be used. For instance, we have used the Customized Probability Index,[11] whereas the DREAM trial used the Glasgow Aneurysm Score (GAS).[12] To determine whether the Glasgow Aneurysm Score was a better predictor of operative mortality than the CPI, we calculated it for UKSAT patients and compared the results with the CPI in the subset of 467 patients who had elective aneurysm repair within 6 months of randomization to the surgery group. The results are available in Appendix (online only). In summary, both scores demonstrated an increase in operative mortality with deteriorating fitness, but the GAS appeared to be a stronger predictor of mortality than the CPI when logistic regression was used to investigate the relationship between scores and risk of death. The CPI was developed for use in all patients undergoing vascular surgery and the type of surgery was one of the strongest prognostic indicators for operative mortality. In our analysis, nearly all patients underwent open aneurysm surgery but the components developed for this score will also have been influenced by the inclusion of patients undergoing other types of surgery such as carotid endarterectomy and infrainguinal bypass grafting. This may have had an impact on the predictive ability of this score when compared to other scores developed and validated only in patients undergoing aortic aneurysm surgery. However, for both the UKSAT and EVAR trial 1, the CPI demonstrates a trend of increasing operative mortality as fitness deteriorates, although the increase appears to be more marked for the UKSAT (2.2% increasing to 6.0%, Appendix, online only) compared with the EVAR trial 1 patients (4.1% increasing to 4.9%).[11]

We expected the CPI scores of patients in UKSAT to be higher than those in the EVAR trial 1 which began recruitment in 1999, since in the former trial of the early 1990s very few patients were taking either of the protective scoring medications (beta-blockers and statins) and data for scoring the cerebrovascular disease component were unavailable in EVAR 1. However, despite these differences in fitness and medical therapy between EVAR 1 and the UKSAT, the ADAM trial which recruited during the mid-1990s included younger patients of even better fitness with improved medical therapy and still did not demonstrate any benefit in the early surgery group.

Following several different aneurysm screening trials and a recent Cochrane Review,[22-25] the benefits of screening to reduce aneurysm-related mortality are clear. National screening programs are being developed in several countries. However, there is no evidence from randomized trials about the best surveillance program for small AAAs. The results of the present analysis indicate that surveillance and intervention policies might need to be tailored to patient fitness. Similarly, for large aneurysms intervention polices should be tailored to fitness, since the EVAR trial 2 showed that for unfit patients a policy of early endovascular intervention conferred no survival advantage compared with a policy of no intervention.[26]

CONCLUSIONS

The conclusions of the UKSAT and the ADAM trial remain unchanged as there is little benefit to be achieved by operating early on patients with small AAA measuring between 4.0 and 5.5 cm. Regular surveillance until the aneurysm grows to 5.5 cm is a safe, non-invasive and less costly management policy. Even with very low operative mortalities of 2% as seen in the fittest patients of this cohort, there is no evidence to suggest any benefit in operating early. However, the unexpected finding that less fit patients may benefit from early surgery requires further investigation in other independent studies or meta-analysis. It is possible that the statistical significance of this benefit is a type 1 error, specific to this sample of patients enrolled in the UKSAT. It is also possible that our choice of the customized probability index has demonstrated an erroneous result that would not be seen with other prognostic risk scores. Thus, we would encourage others to investigate whether these results can be reproduced in other series. If they can, then it is possible that fitness rather than AAA diameter should be the primary consideration in the decision on when to repair an AAA.

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AUTHOR CONTRIBUTIONS

Conception and design: LB, JP
Analysis and interpretation: LB, JP, ST
Data collection: UKSAT Participants, RG lead applicant
Writing the article: LB, JP
Critical revision of the article: LB, JP, ST, RG
Final approval of the article: LB, JP, ST, RG
Statistical analysis: LB, ST
Obtained funding: RG, JP
Overall responsibility: LB

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