ORIGINAL ARTICLES

Abdominal aortic aneurysm rupture rates: A 7-year follow-up of the entire abdominal aortic aneurysm population detected by screening

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Purpose: **The goal of the current study was to identify the risk of rupture in the entire abdominal aortic aneurysm (AAA) population detected through screening and to review strategies for surgical intervention in light of this information.**
Methods: **Two hundred eighteen AAAs were detected through ultrasound screening of a family practice population of 5394 men and women aged 65 to 80 years. Subjects with an AAA of less than 6.0 cm in diameter were followed prospectively with the use of ultrasound, according to our protocol, for 7 years. Patients were offered surgery if symptomatic, if the aneurysm expanded more than 1.0 cm per year, or if aortic diameter reached 6.0 cm.**
Results: **The maximum potential rupture rate (actual rupture rate plus elective surgery rate) for small AAAs (3.0 to 4.4 cm) was 2.1% per year, which is less than most reported operative mortality rates. The equivalent rate for aneurysms of 4.5 to 5.9 cm was 10.2% per year. The actual rupture rate for aneurysms up to 5.9 cm using our criteria for surgery was 0.8% per year**
Conclusion: **In centers with an operative mortality rate of greater than 2%, (1) surgical intervention is not indicated for asymptomatic AAAs of less than 4.5 cm in diameter, and (2) elective surgery should be considered only for patients with aneurysms between 4.5 and 6 cm in diameter that are expanding by more than 1 cm per year or for patients in whom symptoms develop. In centers with elective mortality rates of greater than 10% for abdominal aortic aneurysm (AAA) repair, the benefit to the patient of any surgical intervention for an asymptomatic AAA of less than 6.0 cm in diameter is questionable.**
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The clinical decision to operatively or conservatively manage a patient with an AAA is dependent on the risk of rupture compared with the risk of planned operation. Previous work has reported rupture rates based on highly selected groups of patients with aneurysms diagnosed either through clinical examination or during the course of investigation for other pathology.[1-4] There would inevitably be a higher proportion of larger or symptomatic aneurysms within these patient groups, and therefore entire population rupture rates cannot be accurately determined.[1,4] The natural history of aortic rupture in a screened population (i.e., a sample as near as possible representative of the entire population) is vitally important in decision making for individual patients. If the mortality rate from elective surgery in an individual vascular care unit exceeds the rupture rate for an aneurysm of a specified size, then elective surgery should be deferred until clearly defined criteria for surgery are met.

Ultrasound is able to assess aortic diameter in more than 97% of the population[5,6]; therefore, by

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Table I. Annual rupture rates and elective operation rates for aortic aneurysms according to initial size based on a mean follow-up of 5.7 years

AAA diameter	*No. of AAAs*	*No. of ruptures*	*Rupture rate per year*	*No. of elective operations*	*Operation rate per year*	*MPR rate per year*
3.0 to 4.4 cm	135	5	0.7%	11	1.4%	2.1%
4.5 to 5.9 cm	31	3	1.7%	15	8.5%	10.2%
Total	166	8	0.8%	26	2.7%	3.5%

AAA, Abdominal aortic aneurysm; *MPR*, maximum potential rupture.

using this as a screening tool, the true prevalence of AAA in a population can be determined. Serial follow-up of this population, including the use of ultrasound, can determine true expansion and rupture rates. The decision of when to operate on an aneurysm should then be based on specific criteria. We recently outlined criteria for operation based on maximum aortic diameter, expansion rate, and symptoms related to the aneurysm.[5] Recent results from our prospective randomized trial of aortic screening in a male population confirmed that through screening and adherence to these criteria for surgery, the risk of aortic rupture is reduced.[7]

With the current interest in small aneurysms generated by the UK Small Aneurysm Trial,[8] our aim was to determine the rupture rates for AAAs of less than 6.0 cm in diameter and to compare them with our operative mortality rates.

METHODS

Ethical approval for this study was granted by the local ethics committee. Men and women between the ages of 65 and 80 years were identified from the local Family Health Services Authority (FHSA) list. In the United Kingdom, the FHSA registers patients with their general practitioner (GP), or family physician. A randomly selected sample were invited by letter from their GP to attend a screening clinic at their local practice or at a local hospital. Recruitment occurred from 1988 through 1991, and follow-up data were obtained up to the end of 1995.

At the initial visit, a research nurse administered a medical history questionnaire. Subjects then underwent B-mode ultrasound (Siemens, Sunbury, U.K.) examination of the aorta in longitudinal and transverse axes. The maximum aortic diameters in both transverse and anteroposterior planes were recorded, and hard-copy printouts were made of abnormal aortas and normal scans for quality control purposes. An abdominal aortic aneurysm was defined as an aortic diameter of at least 3.0 cm in either plane.[6] The subject's GP was informed of any abnormal ultrasound findings and the proposed schedule of follow-up.

Subjects with an aortic diameter of 3.0 to 4.4 cm were offered repeat ultrasound scans at yearly intervals to detect expansion. Those with an aortic diameter of 4.5 to 5.9 cm were scanned at 3-month intervals. Patients with an aneurysm of 6.0 cm or greater in diameter were referred for urgent clinical assessment and operation if appropriate. Subjects were reviewed by a clinician at the time of their third scan or if the following prospective criteria for surgical intervention were met: an aneurysm expansion rate of greater than 1.0 cm per year on repeat ultrasound scan, an aortic diameter of 6.0 cm or greater, and a symptomatic aneurysm of any size.

Mortality data for those who died during the period of follow-up were obtained from the Registrar of Births and Deaths in the Chichester District, and details of hospital admissions were obtained from the Accident and Emergency Register, the Operating Theatre Register, and the hospital mortuary.

RESULTS

Seven thousand eight hundred eighty-seven subjects were sent a letter inviting them to be screened for an AAA; 5394 subjects (68.4%) accepted the invitation (2342 men and 3052 women). Ultrasound demonstrated 218 AAAs, resulting in a prevalence rate of 4.0% for men and women in the age group of 65 to 80 years (median age: men, 71 years; women, 72 years): the prevalence rate was 7.6% for men. One hundred eighty-three subjects had follow-up with repeat ultrasound, of whom 166 had an AAA of less than 6.0 cm and 17 had an AAA of at least 6.0 cm in diameter.[7]

Thirty-five (35 of the 218 subjects) subjects did not attend their first recall appointment. They were lost to follow-up and are not included in the subsequent results because they did not have a second ultrasound scan. One third (11) did not attend because they had died before the next appointment

Table II. Comparison of maximum potential rupture rate of aortic aneurysms according to initial size and 30-day operative mortality rates[9]

AAA diameter	*MPR rate per year*	*Mortality rate for elective operation*	
3.0 to 4.4 cm	2.1%	Elective (n = 72)	1.4%
4.5 to 5.9 cm	10.2%	Symptomatic (n = 58)	3.5%
Total	3.5%		2.3%

AAA, Adominal aortic aneurysm; *MPR*, maximum potential rupture.

date (none died of a ruptured AAA). One fourth (nine patients) declined follow-up because they were not well as a result of other causes, (four of whom died subsequently, none as a result of a ruptured AAA); three moved away (one of whom subsequently died, not from ruptured AAA). This leaves one third of the 35 (12) whose lack of attendance was unexplained. Two of these 12 died of ruptured AAA and 2 other patients developed symptoms, leading to operation with successful outcome.

Of these 35 subjects who did not attend follow-up, there was only one patient with an AAA of 4.5 to 5.9 cm in diameter. He is alive (on recent contact with his GP) without having undergone operation for the AAA. The mortality rate from rupture in patients with an AAA of 4.5 to 5. 9 cm in this group therefore was 0% over this observation period.

In the 166 patients who had more than one ultrasound examination and had an AAA of less than 6 cm in diameter, the mean follow-up time for the group was 5.7 years (range, 4.6 to 7.2 years). From 2 to 21 ultrasound scans were performed for each patient. Of these 166 patients with AAAs who were followed, 135 had an initial diameter of 3.0 to 4.4 cm and 31 had a diameter of 4.5 to 5.9 cm.

The rupture rate (deaths and emergency operations) for aneurysms of less than 6.0 cm at initial scan and the rate of elective operation for the criteria defined above are given in Table I. The quoted maximum potential rupture rate assumes that all patients operated on according to our criteria for surgery had an AAA that would have ruptured. During the follow-up (mean, 5.7 years) 8 of the 166 who were followed with two or more ultrasound scans presented with a ruptured AAA (4.8%).

Five patients (3.7%) who had an aortic diameter of 3.0 to 4.4 cm at their initial ultrasound scan had a ruptured aneurysm at a mean follow-up time of 65.8 months. The aortic diameter at the last scan before rupture was greater than 6.0 cm in two patients (who had been unfit for or declined operation), not measured in two patients who declined follow-up after their second or subsequent scan, and 3.0 cm in one patient in whom rupture occurred 4 days after operation on the colon. Two patients in this group underwent successful emergency operation. We previously reported 30-day operative mortality rates of 1.4% for asymptomatic aneurysms and 3.5% for symptomatic nonruptured aneurysms (with a combined mortality rate of 2.3%).[9] There was no statistically significant difference between this reported combined mortality rate and the above rupture rate of small aneurysms (95% confidence interval for a difference in proportions, – 0.026 to 0.055; $p = 0.49$).

Three patients (9.7%) with an aortic diameter of 4.5 to 5.9 cm at the initial scan ruptured at a mean follow-up of 19.4 months. The aortic diameter at the last scan before rupture was greater than 6.0 cm in two patients and 5.1 cm in one patient (2 years before rupture). All patients had declined operation or further follow-up. One of these patients subsequently survived emergency operation. This rupture rate is at least fourfold greater than our 30-day mortality rates, although the values are not statistically significant (95% confidence interval for the difference in proportions, – 0.033 to 0.181; $p = 0.15$).

Table II shows the maximum potential rupture rate in comparison with the operative mortality rate according to initial aneurysm diameter.

DISCUSSION

Ultrasound screening of AAA based on general practice is feasible[10] and has the potential to decrease the incidence of aortic rupture.[1] Aortic rupture has an overall mortality rate of 80% to 90%[11] and an operative mortality rate of 50%[12-14] in many reported series. A ruptured AAA is responsible for 1.2% of deaths in men in the United Kingdom over the age of 65 years.[7] It therefore is a significant health problem. A recent review suggested, however, that screening for AAA does not fulfill all the criteria for a screening program and that further longitudinal outcome data are required.[15]

In our district, the screened prevalence of an AAA of more than 3.0 cm diameter was 4.0% in men and women (7.6% in men only), which is similar to that reported from other studies.[16-18] The accuracy of our ultrasound measurements of the aortas was assessed; there was a difference of less than 5 mm between ultrasonographers.[19]

There is controversy regarding the absolute indications for operative intervention. Elective operation is justified if the risk of death or disability from the operation is less than that from the natural history of the disease.[20] In terms of aortic diameter, sizes ranging from 4.0 cm[20,21] to 6.0 cm[14] have been proposed as indications for aortic surgery. One opinion was that aortas of less than 4.0 cm in diameter be considered "meta-aortas" rather than true aneurysms because there is a natural age-related increase in aortic diameter with minimal risk of rupture.[6] Nevitt et al.[4] reported 5-year rupture rates of 0% for AAAs of less than 5 cm in diameter and 25% for AAAs of greater than 5 cm in diameter in 181 aneurysms of patients who presented clinically. A review of work from the Veterans Administration Medical Center in Vermont suggests annual true rupture and acute expansion rates of 0% for AAAs of less than 4.0 cm, 3.3% for AAAs of 4.0 to 4.9 cm, and 14.4% for AAAs of at least 5.0 cm in diameter.[22] On the basis of this information, it was suggested that early operation is beneficial for patients presenting with an AAA of at least 4.0 cm. In a further report, the same authors used computer modeling of life expectancy based on literature-derived estimates of patient outcome.[20] The figures were based on 60-year-old men with a 4.0 cm AAA, a 5% elective operative mortality rate, and a 3.3% annual rupture rate. The model suggested that AAA repair at a diameter of 4.0 cm would increase survival by 0.34 quality-adjusted life-year (QALY) at an increased cost of $17,404 per QALY compared with observation only of the aneurysm. The cost is significantly less than the "acceptable" cost-effectiveness ratio of $40,000 per QALY.[20] Interestingly, Lederle[23] reported a recent survey of members of the Society for Vascular Surgery that showed that the estimated rupture rate for AAA for individual surgeons was higher than the literature suggests. Large population-based studies are therefore imperative to determine true rupture rates and enable the correct decision to be made.

Thirty-five (16%) of the subjects with a screening-detected AAA were excluded because they did not attend their first follow-up scan. If this group included large numbers who died of rupture, the conclusions on the remaining patients might be invalid. The majority did not attend because they had either died or were ill from another cause, and none of these had died of a ruptured AAA. The risk of rupture is related to aortic diameter. If a large proportion of the 35 subjects had an AAA of greater than 4.5 cm, there could have been a considerable risk of rupture due to failure of initial follow-up, but only one subject in the group had an AAA of 4.5 to 5.9 cm, and he remains well, strongly suggesting that follow-up in the "at-risk" group is well attended, so the risk of rupture from failed follow-up is low.

Our results in the remainder of patients who attended follow-up show that provided the patient does not develop symptoms and the expansion rate is less than 1 cm per year, observation of aneurysms with a diameter of less than 6.0 cm results in lower actual rupture rates (0.8% per year) than any published 30-day elective operative mortality values. Autopsy studies have shown that at least 50% of patients with aortic aneurysms die of other causes,[24] so surgical treatment in this group would not have increased life expectancy. A further study found that 82% of aneurysms of less than 5.0 cm in diameter had not ruptured at post mortem.[25] The cost of treatment is a major factor in the total cost of screening. A reduction in the size at which operation is indicated from 6.0 cm to 5.0 cm has been calculated to increase the cost per QALY gained from £7,300 to £20,000[26] ($12,800 to $35,100).

Our figures show that the maximum potential rupture rate (assuming that all elective operative cases would have ruptured without surgery) is 2.1% per year for aneurysms of 3.0 to 4.4 cm. This compares favorably with the reported 30-day operative mortality rate of 2% to 10% for elective aneurysms in large centers.[12,27-29] We therefore suggest that in centers with mortality rates for elective surgery of greater than 2.1%, elective operation for asymptomatic AAAs with a diameter of less than 4.5 cm appear not to be in the patient's best interest.

The situation is slightly different for aneurysms of 4.5 to 5.9 cm in diameter on initial screening, which have an actual rupture rate of 1.7% per year and a maximum potential rupture rate of 10.2% per year. As stated in our previous work,[7,30] if our criteria for planned surgery are applied, observation is preferable to surgery in patients with an AAA diameter up to 6.0 cm. This appears to apply even in centers with some of the best reported operative results. In units with elective surgical mortality rates of greater than 10%, our results strongly suggest that surgery is more hazardous than no treatment at all. Our 10.2% maximum potential rupture rate per year assumes the unlikely event that all the aneurysms treated surgically would have ruptured in year 1. If this was not the case, this conclusion might well apply for more than 1 year.

Conclusions. In centers with an operative mortality of greater than 2%, (1) operative intervention for asymptomatic AAAs of less than 4.5 cm in diameter is not indicated, and (2) elective surgery should be considered only for patients with aneurysms between 4.5 and 6 cm in diameter that are expanding by more than 1 cm per year or for patients in whom symptoms develop.

In centers with elective mortality rates of greater than 10% for AAA repair, the benefit to the patient of any operative intervention for an asymptomatic AAA of less than 6.0 cm in diameter is questionable.

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