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Prognosis in Elderly Men with Screening-detected Abdominal Aortic Aneurysm*

Mats Ögren[1], Henrik Bengtsson[2], David Bergqvist[3], Olle Ekberg[4], Bo Hedblad[1] and Lars Janzon[1]

Departments of Community Health Sciences[1], Surgery[2], and Radiology[4], Lund University, Malmö General Hospital and the Department of Surgery, Akademiska Sjukhuset Uppsala University[3], Sweden

Objectives: *To study the natural course of screening-detected symptomless abdominal aortic aneurysm (AAA) in elderly men.*
Setting: *Malmö, a city in southern Sweden with 230 000 inhabitants and a single referral hospital.*
Materials: *423 seventy-four-year-old men, randomly selected from the population and belonging to the prospective population study "Men born in 1914", were invited. 343 underwent AAA screening, whereas 80 declined or had moved.*
Chief outcome measures: *Five year all cause mortality in relation to participation in and findings at ultrasound screening for AAA.*
Main results: *An abdominal aortic aneurysm was present in 38 (11%) out of 340 men who underwent screening and who had a native aorta. During 5 years of follow-up, one third (13/38) of these men died; 7 from myocardial infarction and 3 from stroke. The mortality rate in men with AAA was 80.2/1000 person years; twice as high as it was in men without AAA (39.4/1000 person years;* $p = 0.018$*). Six men underwent AAA surgery. None of them died from aneurysm rupture. However, aneurysm surgery did not reduce the total mortality rate in these men. The highest mortality rate, 91.9/1000 person years, was found in the men who did not participate in the screening.*
Conclusions: *It is our conclusion that screening for early detection and intervention is of questionable value from a public health perspective.*

Introduction

Ultrasound screening for detection of asymptomatic abdominal aortic aneurysm (AAA) has been recommended by some as a solution to the poor prognosis of patients with imminent or manifest rupture of AAA.[1,2] Screening remains a controversial issue.[3–5] The increased morbidity and mortality from myocardial infarction and stroke in aneurysm patients has been documented in several clinical studies.[6–9] A successful screening programme should not only lead to early detection and treatment. Above all, the objective should be to avoid premature death.

This study from the prospective population study "Men born in 1914" deals with the natural course of AAA in a cohort of 74-year-old men, invited for screening by ultrasound.

Materials and methods

Study cohort

The cohort study "Men born in 1914", Malmö, Sweden, was designed to investigate cardiovascular and pulmonary disease, and has been running since 1969.[10] In 1982/1983, all men born in the even months of 1914 and residing in Malmö were invited to a health examination close to their 68th birthday. Of 621 invited, 500 (76.8%) participated in this examination which included assessment of smoking habits and measurements of blood pressure and of plasma lipids. A limited assessment of atherosclerotic risk factors was also made in the 121 non-participants.[11]

Between 1983 and 1988, 77 (15.4%) of the 500 men who took part in the 1982/1983 health examination had died. The remaining 423 men that in 1988 were

*Results from 5-year follow up of the prospective population study "Men born in 1914", Malmö, Sweden.

Please address all correspondence to: Dr Mats Ögren, Department of Community Health Sciences, Lund University, Malmö General Hospital, S-214 01 Malmö, Sweden.

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eligible were invited to attend for ultrasound screening to detect abdominal aortic aneurysm (AAA). Three-hundred and forty-three (81.1%) participated, whereas 12 (2.8%) had moved from the city, and another 68 (16.1%) declined participation.

Ultrasound examination of the abdominal aorta

All examinations were performed by a single, specially trained radiologist.[12] Real-time equipment (Hitachi 400 linear array) was used. Three subjects, who previously had undergone abdominal aortic graft surgery, were excluded from further analysis. Mean (± 1 S.D.) external aortic diameter was, at the level of the coeliac trunk, 25 ± 3 mm, and the median diameter (10th–90th percentile) was 25 (22–30) mm. Corresponding estimates of the external aortic diameter at the aortic bifurcation level were 20 ± 6 mm, and 19 (16–25) mm, respectively.

The normal aorta tapers distally and the main criterion for normality was such tapering. Any local aberration from this was measured and the diameter and length of any such bulging measured. An abdominal aortic aneurysm (AAA), defined either as a bulging of the abdominal aorta or as an external aortic diameter exceeding 35 mm, was present in 38 (11.1%) out of 340 subjects. In 21 of the men, the AAA was larger than 30 mm, and in six the diameter exceeded 50 mm. All men with an AAA were referred to the department of vascular surgery. The decision whether to treat the aneurysm surgically or to follow it by repeat ultrasound examinations was made by the vascular surgeons involved in the study.

Risk factors for atherosclerotic disease

Systolic and diastolic (phase V) blood pressure was measured sphygmomanometrically with the subject in a sitting position after 15 min of rest. Blood pressure was recorded to the nearest 5 mm Hg. Hypertension was defined as systolic or diastolic brachial blood pressure ≥160/95 mm Hg or medication for hypertension.[13] Plasma cholesterol levels were analysed by standard methods and expressed in mmol/1.[14] Smoking habits were assessed by means of a structured questionnaire. The men were considered to be either current smokers; ex-smokers (who had quit at least a month prior to investigation); or non-smokers.

Mortality surveillance

All abdominal ultrasound examinations were carried out during March and April 1988. To create similar follow-up conditions in participants and non-participants, the follow-up for each subject commenced on April 1st, 1988, and continued until his death or until March 31st, 1993. Mortality data were obtained from the Mortality Register of the Swedish National Bureau of Statistics. In 47.5% (47/99) of the deaths, an autopsy was performed. Cases coded 410.0–412.9 according to the ICD code, 8th revised version, were registered as deaths from ischaemic heart disease (IHD), and cases coded 430.0–438.441.9 as deaths from cerebrovascular disease (CBD). Cases coded 441.0–9 were considered as deaths from aortic aneurysm; and, especially, cases coded 441.20 were regarded as deaths from AAA. Mortality rates were expressed as deaths per 1000 person years of observation.

Statistical methods

Survival analysis, using the Kaplan-Meier method with the generalised Wilcoxon test was used to study mortality in men with and without AAA, and in men who did not participate in the ultrasound examination.[15] In the analysis of risk factors, 95% confidence intervals (CI) were calculated around the estimates of means and of proportions, and the chi-square test was used to evaluate difference in AAA prevalence in relation to presence of risk factors.

Results

Mortality in screening-detected AAA

Thirteen (34%) of the 38 men with abdominal aortic aneurysm (AAA) died during the 5-year follow-up period (Tables 1 and 2). Twelve (92%) of the deaths were caused by atherosclerosis-related diseases: seven men died from ischaemic heart disease (IHD), three from cerebrovascular disease (CBD), one from ruptured AAA, and another from dissecting aneurysm of the thoracic aorta (Tables 1 and 2). Only one death from non-vascular cause (pulmonary carcinoma) occurred in this group. Six of the men underwent elective aneurysm resection during the course. Three of them died later during the follow-up period; two from IHD and one from CBD (Table 1).

Of the 302 men without signs of AAA at 74 years of

Table 1. Course during 5-year follow-up of 74-year-old men with abdominal aortic aneurysm (AAA) at ultrasound screening

Case no.	AAA measurements		Aneurysm resection		Death	
	Diameter (mm)	Length (mm)	Follow-up time (months)	Indication	Follow-up time (months)	Cause of death
1	21	33	–	–	–	–
2	21	21	–	–	–	–
3	24	20	–	–	30	IHD
4	25	36	–	–	–	–
5	25	...	–	–	–	–
6	26	27	–	–	–	–
7	26	80	–	–	4.5	IHD
8	27	28	–	–	52	IHD
9	27	26	–	–	7.5	Ca pulm
10	28	30	–	–	–	–
11	28	33	–	–	–	–
12	29	80	–	–	14	IHD
13	29	75	–	–	–	–
14	29	32	–	–	–	–
15	29	63	–	–	58	diss. AA
16	30	70	–	–	–	–
17	30	64	–	–	–	–
18	31	70	–	–	–	–
19	32	52	–	–	–	–
20	32	46	–	–	–	–
21	34	27	–	–	–	–
22	35	45	–	–	–	–
23	35	55	–	–	37	CBD
24	35	72	–	–	–	–
25	39	61	–	–	–	–
26	42	35	–	–	–	–
27	45	76	–	–	–	–
28	47	67	–	–	–	–
29	47	72	–	–	40	IHD
30	47	63	–	–	–	–
31	48	75	2	Elective	39	IHD
32	50	90	2	Elective	54	CBD
33	51	60	–	–	47	AAA
34	55	150	19.5	Elective	–	–
35	60	60	3.5	Elective	58	IHD
36	60	77	33	Elective	–	–
37	61	94	19	Elective	–	–
38	70	100	–	–	8.5	CBD

age, 54 (18%) died during follow-up (Table 2). Of these, 12 (22%) died from IHD, seven (13%) from CBD and five (9%) from other cardiovascular causes, whereas 19 (35%) died from neoplasms and 11 (20%) from other causes (Table 2). The highest mortality (38%) was found in the 80 men who did not participate in the ultrasound screening examination. Nine (30%) of the 30 deaths in this group were due to IHD. One of the non-participants died postoperatively after emergency surgery for a ruptured, 8 cm AAA (Table 2). The mortality rate, expressed as deaths per 1000 person years of observation, was 39.4 in men without AAA at screening (Table 3) (Fig. 1). Men with AAA had a twice as high mortality rate (80.2 deaths/1000 person years) ($p = 0.018$), whereas it was 91.9 ($p < 0.001$) in non-participants.

Table 2. Causes of death during 5 years of follow-up of 74-year-old men in relation to participation in and findings at ultrasound screening of the abdominal aorta

	No AAA	AAA	Non-participants
Number of men	302	38	80
Number of deaths	54	13	30
Causes of death			
AAA	0 (0%)	1 (7.7%)	1 (3.3%)
Other aortic aneurysm	0 (0%)	1 (7.7%)	0 (0%)
IHD	12 (22.2%)	7 (53.8%)	9 (30.0%)
CBD	7 (13.0%)	3 (23.1%)	3 (10.0%)
Other CVD	5 (9.2%)	0 (0%)	3 (10.0%)
Neoplasms	19 (35.2%)	1 (7.7%)	7 (23.3%)
Other causes	11 (20.4%)	0 (0%)	7 (23.3%)

Risk profile in men with and without AAA

Of men with AAA at 74 years of age, 79% had

Table 3. Five year all cause mortality rate in 74-year-old men in relation to participation in and finding at ultrasound screening for abdominal aortic aneurysms (AAA)

Group	Ultrasound screening	*n*	Total mortality				
			Number of deaths (%)	Total follow-up time (years)	Deaths/1000 person years	*p*-value when compared with	
						Group 1	Group 2
1	No AAA	302	54 (17.9%)	1371.9	39.4		
2	AAA	38	13 (34.2%)	162.2	80.2	0.018	
	Not operated AAA; diameter <30 mm	15	6 (40.0%)				
	Not operated AAA; diameter ≥30 mm	17	4 (23.5%)				
	Operated AAA	6	3 (50.0%)				
3	Non participants	80	30 (37.5%)	326.5	91.9	<0.001	0.657

hypertension at a health examination 6 years before (95% CI 66–92%). Ninety per cent (95% CI 87–93%) were or had been smokers, and 29% (95% CI 15–43%) had a history of IHD, defined as angina pectoris or previous MI at 68 years of age (Table 4). In comparison, 58% (95% CI 53–64%) of men without AAA had hypertension; 79% (95% CI 74–84%) had a history of smoking, and 14% (95% CI 10–18%) had IHD. The prevalence of hypertension in men with AAA was not different between those who died (77%; 95% CI 54–99%) and those who survived (80%; 95% CI 64–96%) during follow up (Table 4). In men without AAA at ultrasound screening, and in men who did not participate in the screening, hypertension had been present in a larger proportion of those who died (71%; 95% CI 59–83%, and 70%; 95% CI 53–88%, respectively), compared with survivors (55%; 95% CI 49–62%, and 63%; 95% CI 49–77%, respectively). All men who had screening-detected AAA and who died during follow up were or had been smokers (Table 4). Three-quarters of them were still active smokers at the age of 68, compared with 28% of those men with AAA who survived, and with 31% of the men who were free from AAA. Plasma cholesterol levels at 68 years of age

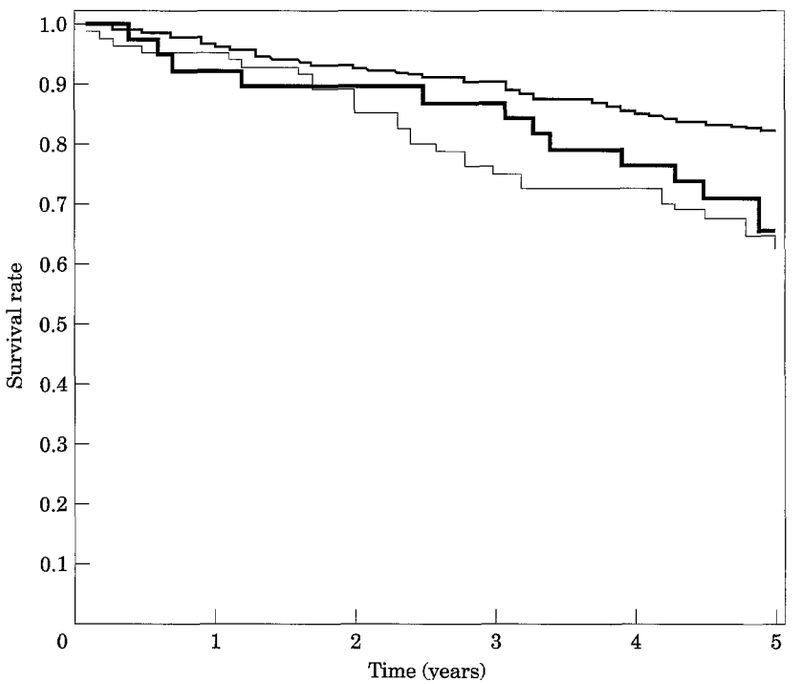

Fig. 1. Five year survival rates in 74-year-old men in relation to participation in ultrasound screening for abdominal aortic aneurysm (AAA), and to the result of the screening procedure. (▬) AAA; (——) No AAA; (– – –) Non-participants.

Table 4. Atherosclerotic risk factors at 68 years of age in relation to abdominal aortic aneurysm (AAA) screening results and to survival during 5 years of follow-up in 74-year-old men

Ultrasound screening at 74	Outcome of 5-year follow-up	*n*	Hypertension at 68 (%)†	IHD at 68 (%)†	Plasma cholesterol at 68 (mmol/l)‡	Smoking habits at 68 (%)†		
						Never smokers	Ex-smokers	Current smokers
No AAA	All men	302	58 (53–64)	14 (10–18)	6.0 (5.9–6.1)	21 (17–26)	48 (42–54)	31 (26–36)
	Alive	248	55 (49–62)	14 (10–18)	6.0 (5.9–6.1)	24 (19–30)	44 (37–50)	32 (26–38)
	Dead	54	71 (59–83)	14 (4–23)	5.9 (5.5–6.2)	7 (0–14)	69 (56–81)	24 (13–36)
AAA	All men	38	79 (66–92)	29 (15–43)	6.2 (5.9–6.5)	10 (1–20)	45 (29–60)	45 (29–60)
	Alive	25	80 (64–96)	24 (7–41)	6.1 (5.7–6.5)	16 (2–30)	56 (37–75)	28 (10–46)
	Dead	13	77 (54–99)	39 (12–65)	6.3 (5.6–6.9)	0 (0– 0)	23 (0–46)	77 (54–99)
Non participants	All men	80	66 (55–77)	22 (12–31)	6.0 (5.8–6.3)	17 (8–26)	41 (30–52)	42 (31–53)
	Alive	50	63 (49–77)	24 (12–36)	6.1 (5.8–6.3)	15 (5–26)	41 (27–55)	44 (29–58)
	Dead	30	70 (53–88)	18 (4–32)	5.8 (5.4–6.5)	20 (6–34)	40 (22–57)	40 (22–57)

† 95% confidence interval around the estimated proportion.
‡ Mean (95% confidence interval).

were not significantly different statistically when comparing screening participants with and without AAA and non-participants in relation to outcome.

AAA prevalence in relation to presence of risk factors

The prevalence of AAA in 74-year-old men was 11.2% (38/340). In men who still had been smokers at the age of 68 it was 15.5% (17/110), compared with 5.9% (4/68) in never smokers ($p = 0.054$). Men with hypertension had an AAA prevalence of 14.7% (30/204), compared with 6.0% (8/133) in normotensive men ($p = 0.014$). In men with angina pectoris or previous MI the AAA prevalence was 21.2% (11/52), whereas it was 9.5% (27/284) in men without known previous IHD ($p = 0.015$).

Discussion

The high mortality associated with abdominal aortic aneurysm (AAA) concurs with that, documented in many clinical studies.[6–9, 16–17]. However, it should be noticed that the majority of deaths among men with an aneurysm were due to myocardial infarction and stroke, and that in fact only two individuals died from aneurysm rupture. Our observation is in accordance with findings from a large screening programme where rupture was rare in AAAs with a diameter less than 6 cm,[18] and with results from autopsy studies.[19] Whether screening and early treatment leads to a lowered mortality, i.e. whether or not it is efficacious, has to be evaluated in a clinical trial. The results of the U.K. Small Aneurysm Trial are eagerly awaited.[4] The effectiveness of screening on the other hand, i.e. to what extent it in fact affects aneurysm mortality in a community setting, can only be investigated in a population-based study. One prerequisite to obtain reliable results is a very high autopsy rate. Whether or not an increase in elective AAA surgery influences mortality is controversial.[20,21]

Although "Men born in 1914" is a relatively small cohort it does contribute some results that ought to be considered in a discussion about individual and public health benefits associated with screening. The most beneficial effect associated with early detection and treatment in this study was that the six men who were surgically treated might have died from rupture had they not been operated on. This is equivalent to a rise in survival for the entire cohort of 0.8%, which then can be considered an estimate of the maximum public health benefit associated with screening. The high cardiovascular mortality rate associated with AAA in this study and in a similar investigation from our group[22] implies that a screening-detected aneurysm should be considered a marker, similar to leg artery occlusive disease, of generalised atherosclerosis.[23] The associated risk of death from myocardial infarction or stroke also seems to be related to the size of the aneurysm. Whether this non-aneurysm mortality is preventable by antithrombotic treatment, or by other forms of risk factor intervention, remains to be evaluated.

Apart from general screening, screening directed against certain risk groups has been advocated.[24] Our results suggest that selective ultrasound screening of high risk individuals identified on the basis of

smoking habits, blood pressure or previous IHD would yield a higher prevalence of AAA in the screened group. However, as a large proportion of the aneurysms were found among individuals where these risk factors were not present, such a procedure would lead to a low sensitivity i.e. a high proportion of false negatives. It is possible that recently discovered biochemical markers of the aortic wall metabolism may provide a better means for selective AAA screening in the future.[25] Male relatives of patients with AAA have been proposed as high risk groups for AAA screening.[26,27] Although theoretical studies based on decision analysis indicate early surgery (AAA ≥ 4cm) to be more cost-effective than watchful waiting[28] this has to be established in a clinical study, and data from our study cast some doubt on whether or not this will be possible to show.

In conclusion, our results do not indicate that general screening for early detection and treatment of AAA would be a cost-effective way of reducing the mortality from aneurysm rupture in society. The high mortality from myocardial infarction and stroke in individuals whose aneurysms are repaired suggests that early detection and treatment has a very limited effect on the expected survival rate for these patients due to widespread atherosclerosis.

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References

1 Harris PL. Reducing the mortality from abdominal aortic aneurysms: need for a national screening programme. *Br Med J* 1992; **305**: 697–699.
2 Collin J. The value of screening for abdominal aortic aneurysm by ultrasound. In: Greenhalgh RM, Marrick JA, eds. The cause and management of aneurysms. London: WB Saunders Company, 1990.
3 Bergqvist D, Bengtsson H. Should screening for abdominal aortic aneurysms be advocated? *Acta Chir Scand* 1990; **555** (Suppl.): 89–97.
4 Powell JT, Greenhalgh RM, Ruckley CM, Fowkes FGR. Prologue to a surgical trial. *Lancet* 1993; **342**: 1473–1474.
5 Mason JM, Wakeman AP, Drummond MF, Crump BJ. Population screening for abdominal aortic aneurysm: do the benefits outweigh the costs? *J Public Health Med* 1993; **15**: 154–160.
6 Szilagyi DE, Elliott JP. Clinical fate of the patient with asymptomatic abdominal aortic aneurysm and unfit for surgical treatment. *Arch Surg* 1972; **104**: 600–606.
7 Christenson J, Eklöf B, Gustafson I. Abdominal aortic aneurysms: should they all be resected? *Br J Surg* 1977; **64**: 767–772.
8 Liljeqvist L, Ekestrom S, Nordhus O. Abdominal aortic aneurysms. II. Long-term follow-up of operated and unoperated patients. *Acta Chir Scand* 1979; **145**: 529–533.
9 Bardram L, Buchardt Hansen HJ, Dahl Hansen AB. Abdominal aortic aneurysms. Early and late results after surgical and non-surgical treatment. *Acta Chir Scand* 1980; **502**: 85–93.
10 Isacsson S-O. Venous occlusion plethysmography in 55-year-old men. A population study in Malmö, Sweden. *Acta Med Scand* (Suppl. 537) 1972.
11 Janzon L, Hanson BS, Isacsson S-O, Lindell S-E, Steen B. Factors influencing participation in health surveys. Results from prospective population study "Men born in 1914" in Malmö, Sweden. *J Epidemiol Comm Hlth* 1986; **40**: 174–177.
12 Bengtsson H, Bergqvist D, Ekberg O, Janzon L. A population based screening of abdominal aortic aneurysms (AAA). *Eur J Vasc Surg* 1991; **5**: 53–57.
13 1986 Guidelines for treatment of mild hypertension. Memorandum from a WHO/ISH meeting. *J Hypertens* 1986; **4**: 383–386.
14 Boy J, Bonnafé M, Mazet JB. Determination of total cholesterol by a modification of Pearson's method. Its manual and automatic execution. *Ann Biol Clin* 1969; **18**: 69.
15 Armitage P, Berry G. *Statistical methods in medical research.* 2nd edition. Oxford: Blackwell Scientific Publications, 1987.
16 Crawford ES, Saleh SA, Babb III JW, Glaeser DH, Vaccaro PS, Silvers A. Infrarenal abdominal aortic aneurysm. Factors influencing survival after operation performed over a 25-year period. *Ann Surg* 1981; **193**: 699–709.
17 Søreide O, Lillestøl J, Christensen O, Grimsgaard C, Myhre HO, Solheim K. Trippestad A. Abdominal aortic aneurysms: Survival analysis of four hundred thirty-four patients. *Surgery* 1982; **91**: 188–193.
18 Scott RAP, Wilson NM, Kay DN. Is surgery necessary for abdominal aortic aneurysm less than 6 cm in diameter? *Lancet* 1993; **342**: 1395–1396.
19 Bengtsson H, Bergqvist D, Sternby N-H. Increasing prevalence of abdominal aortic aneurysms. A necropsy study. *Eur J Surg* 1992; **158**: 19–23.
20 Eickhoff JH. Incidence of diagnosis, operation and death from abdominal aortic aneurysms in Danish hospitals: results from a nation-wide survey. *Eur J Surg* 1993; **159**: 619–623.
21 Johansson G, Swedenborg J. Little impact of elective surgery on the incidence and mortality of ruptured aneurysms. *Eur J Vasc Surg* 1994; **8**: 489–493.
22 Bengtsson H, Nilsson P, Bergqvist D. Natural history of abdominal aortic aneurysm detected by screening. *Br J Surg* 1993; **80**: 718–720.
23 Ögren M, Hedblad B, Isacsson S-O, Janzon L, Jungquist G, Lindell S-E. Non-invasively detected carotid stenosis and ischaemic heart disease in men with leg arteriosclerosis. *Lancet* 1993; **342**: 1138–1141.
24 Collin J. Screening for abdominal aortic aneurysm. *Br J Surg* 1993; **80**: 1363–1364.
25 Powell J, Greenhalgh RM. Cellular, enzymatic, and genetic factors in the pathogenesis of abdominal aortic aneurysms. *J Vasc Surg* 1989; **9**: 297–304.
26 Bengtsson H, Norrgård Ö, Ängquist KA, Ekberg O, Öberg L, Bergqvist D. Ultrasonographic screening of the abdominal aorta among siblings of patients with abdominal aortic aneurysms. *Br J Surg* 1989; **76**: 589–591.
27 Bengtsson HJ, Sonesson B, Länne T *et al.* Prevalence of abdominal aortic aneurysm in the offspring of patients dying from aneurysm rupture. *Br J Surg* 1992; **79**: 1142–1143.
28 Katz D, Cronenwett J. The cost-effectiveness of early surgery versus watchful waiting in the management of small abdominal aortic aneurysms. *J Vasc Surg* 1994; **19**: 980–981.

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