Multicentre aneurysm screening study (MASS): cost effectiveness analysis of screening for abdominal aortic aneurysms based on four year results from randomised controlled trial

Multicentre Aneurysm Screening Study Group

Abstract

Objective To assess the cost effectiveness of ultrasound screening for abdominal aortic aneurysms.
Design Primary analysis: four year cost effectiveness analysis based directly on results from a randomised controlled trial in which patients were individually allocated to invitation to ultrasound screening (intervention) or to a control group not offered screening. Secondary analysis: projection of the data, based on conservative assumptions, to indicate likely cost effectiveness at 10 years.
Setting Four centres in the United Kingdom. Screening delivered in primary care settings with follow up and surgery offered in the main hospitals
Participants Population based sample of 67 800 men aged 65-74 years.
Main outcome measures Mortality from and costs (screening, follow up, elective and emergency surgery) related to abdominal aortic aneurysm; cost per life year gained.
Results Over four years there were 47 fewer deaths related to abdominal aortic aneurysms in the screening group than in the control group, but the additional costs incurred were £2.2m. After adjustment for censoring and discounted at 6% the mean additional cost of the screening programme was £63.39 ($97.77, €100.48) (95% confidence interval £53.31 to £73.48) per patient. The hazard ratio for abdominal aortic aneurysm was 0.58 (0.42 to 0.78). Over four years the mean incremental cost effectiveness ratio for screening was £28 400 (£15 000 to £146 000) per life year gained, equivalent to about £36 000 per quality adjusted life year. After 10 years this figure is estimated to fall to around £8000 per life year gained.
Conclusions Even at four years the cost effectiveness of screening for abdominal aortic aneurysms is at the margin of acceptability according to current NHS thresholds. Over a longer period the cost effectiveness will improve substantially, the predicted ratio at 10 years falling to around a quarter of the four year figure.

Introduction

The cost effectiveness of unselective ultrasound screening for abdominal aortic aneurysms in older men is uncertain. Previous estimates have been based on small trials[1] or on data from disparate sources.[2–6] Results have ranged from attractive cost effectiveness ratios[1 2 5] to the conclusion that screening was on balance both harmful and costly.[4]

The multicentre aneurysm screening study (MASS) assessed the benefit of screening on mortality related to abdominal aortic aneurysms in a randomised trial. We used data from the trial and calculated reliable unit costs to estimate the cost effectiveness of screening over the observed four year follow up period. In a secondary analysis we estimated cost effectiveness over a longer period.

Methods

Clinical study

The methods for the cost effectiveness analysis build on those of the clinical study fully described elsewhere.[7] In brief, during 1997-9, 67 800 men aged 65-74 years from four centres in the United Kingdom were individually randomised to be invited for screening (intervention arm) or not (control arm). Those who attended for screening underwent ultrasonography of the abdominal aorta with a portable ultrasound machine in a primary care setting. Those found to have a normal aorta (<3 cm diameter) received no further clinical follow up. Those with an aortic diameter of 3.0-4.4 cm were allocated to annual scans in hospital, while those with an aortic diameter of 4.5-5.4 cm were allocated to scans every three months. Men with an aneurysm with an aortic diameter ⩾5.5 cm, rapid expansion (⩾1 cm within one year), or symptoms attributable to the aneurysm were referred to a vascular consultant for assessment of suitability for surgery.

Measurement of costs

We adopted a health service perspective and calculated patient specific costs related to abdominal aortic aneurysms up to four years by applying specifically calculated unit costs of screening (invitation for screening, re-invitation to non-attenders, attendance at screening clinic, and attendance at follow up or recall clinic) and surgery (assessments for suitability, elective repairs, and emergency surgery for rupture). Unless otherwise indicated, cost information at 2000-1 prices

ELPS

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Editorials by Greenhalgh and Powell and by Smith

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The accompanying randomised trial is published simultaneously in The Lancet this week

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was provided by the hospital finance departments of the four centres, supplemented with published information on staff hours.[8]

Costs associated with screening

We based screening clinic costs on the resourcing of screening for this trial and actual throughput of patients. The cost per initial invitation included clerical staff time, postage and stationery, costs of obtaining patient details, and office space and equipment. The cost per clinic attendance included clinic staff time, staff travel costs to primary care locations, disposables, maintenance of screening equipment, charge for clinic rooms, and an annual equivalent cost for equipment. Recall scans for monitoring of the aorta involved the costs of ultrasonography, with only a few patients (8%) seeing a consultant.

Costs associated with surgery

For each of the centres we calculated the cost of an assessment for surgery based on the local procedure and standard investigations. To cost elective and emergency procedures we collected detailed data on use of resources for cohorts of consecutive male patients aged ⩾65 at each centre who were admitted for repair of an aortic aneurysm (360 elective and 217 emergency). Costs were calculated to include any related readmissions during the 12 months after surgery, and were centre specific.

We costed time spent in intensive care, high dependency units, and general surgical wards both before and after surgery using the appropriate hospital bed day costs inclusive of hospital overheads but exclusive of drugs, blood products, and non-pathological investigations (which were costed separately). Theatre time per patient (including any readmissions to theatre related to abdominal aortic aneurysms) was costed to allow for the time of staff involved and the theatre itself. The cost of the specific type of graft inserted during each procedure was included along with a fixed cost for consumables for each centre.

We collected detailed data on drug use for a subsample of 60 patients (emergency and elective) at one centre. We used these data to generate an estimate of total drug costs for each patient in the whole surgery sample. Data on blood products issued were obtained and costed to allow for appropriate handling charges. The non-pathology investigations each patient underwent were costed by using hospital specific unit costs.

For patients discharged to other hospitals and for any admissions related to abdominal aortic aneurysms within 12 months of surgery we applied bed day costs specific for specialty and for the relevant NHS trusts.[9] (See the full version of this paper on bmj.com for more details of the costing methods.)

Representation of cost effectiveness

We measured effectiveness as survival free from mortality related to abdominal aortic aneurysms for each individual up to four years. We included deaths from any cause within 30 days of surgery for aneurysm, elective or emergency. We expressed cost effectiveness as the incremental cost per additional life year gained.[10 11] The probability that screening is cost effective at four years depends on how much the NHS is willing to pay for each life year gained (cost effectiveness acceptability curve).[12] We have indicated the probabilities at a value of £30 000, reflecting the perceived current threshold value per QALY in the United Kingdom.[13]

In the base case analysis we discounted effects in life years at the rate of 1.5% and costs at 6%.[14] We undertook sensitivity analyses to illustrate the impact of the principal aspects of uncertainty on the estimates of cost effectiveness at four years.

Projection of longer term cost effectiveness

We undertook a secondary analysis to provide an indication of longer term cost effectiveness. We restricted this to 10 years and used the following conservative assumptions: that the benefit of screening is restricted to mortality related to abdominal aortic aneurysms; that those for whom such deaths were prevented are subject to the same "other cause" mortality as the general population; that in years 5-10 the absolute risk reduction in such mortality accumulates at only half the rate of that observed in years 2-4; and that the excess annual cost resulting from screening (recall scans and elective surgery) observed in years 2-4 continues during years 5-10.

Results

Resource use and unit costs

Table 1 shows the overall number of events observed in each arm. The initial screening of 27 147 patients generated 4735 follow up or recall scans. Elective and emergency surgery occurred in both arms, with a higher rate of elective surgery (307 *v* 85) and a lower rate of emergency surgery (23 *v* 53) in the intervention arm. Table 1 also summarises the unit costs estimated for these observed events. (See the full version of this paper on bmj.com for more details.)

The mean cost (including any related readmissions within 12 months) for an elective aneurysm repair was £6909 compared with £11 176 for emergency surgery. Increased intensive care unit costs in the emergency surgery group made the biggest contribution to this difference (mean intensive care unit cost: £2528 for elective surgery compared with £5843 for emergency surgery).

Costs of screening and surgery

The total additional costs in the intervention group were £2.2m (table 1). The mean cost of screening per patient randomised in the intervention group (unadjusted for censoring) was £23.23. The mean cost per patient randomised of all surgery related to abdominal aortic aneurysms was £76.64 in the intervention group and £35.93 in the control group.

Cost effectiveness at four years

Cost effectiveness at four years is summarised in table 2. The difference between the arms of the trial in overall mean costs (after adjustment for censoring and discounting at 6%) was £63.39 (£53.31 to £73.48) per patient. Figure 1 shows the reduction in mortality related to abdominal aortic aneurysms in the intervention group compared with the control group (hazard ratio 0.58, 0.42 to 0.78); the numbers of deaths up to four years were 58 and 105, respectively. The mean survival time free from mortality related to abdominal aortic aneurysms was thus greater in the intervention group than the control group, the mean difference (after discounting at 1.5%) being 0.82 days per patient over four years (0.16 to 1.47 days). This gives an

Table 1 Events and costs over four year follow up after randomisation

	No of events during follow up			Total cost (£)	
	Intervention (n=33 839)	Controls (n=33 961)	Cost of event (£)	Intervention	Controls
Costs related to screening:					
Invitation	33 839	0	1.31	44 329	0
Re-invitation	4 602	0	1.28	5 891	0
Initial screening	27 147	0	19.08	517 965	0
Recall scan	4 735	0	46.04	217 999	0
Subtotal				786 184	0
Costs related to surgery:					
Consultation before elective surgery	695	131	309.88	215 367	40 594
Elective surgery	307	85	6 908.75	2 120 986	587 244
Emergency surgery	23	53	11 175.63	257 039	592 308
Subtotal				2 593 392	1 220 146
Total*				3 379 576	1 220 146

*Total cost per patient randomised: intervention group £23.23 (screening) + £76.64 (surgery)=£99.87; control group £35.93 (surgery only).

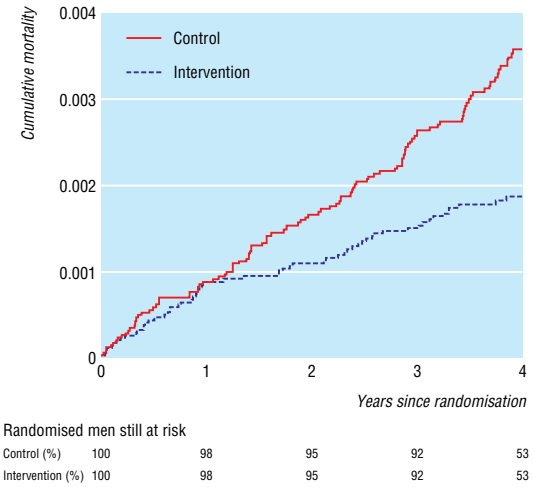

Fig 1 Mortality related to abdominal aortic aneurysms over four years of follow up by randomised group

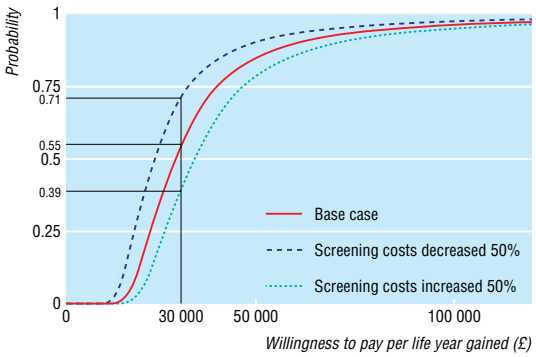

Fig 2 Cost effectiveness acceptability curves (probability that screening is cost effective after four years plotted as function of sum willing to be paid per life year gained) for base case and key sensitivity analyses, based on four years of follow up

estimated incremental cost effectiveness ratio at four years of £28 400 per life year gained (£15 000 to £146 000). This figure corresponds to a cost per quality adjusted life year (QALY) of about £36 000, given an average utility level of around 0.8 for this elderly population.[7 15]

Sensitivity analysis

Full details of our sensitivity analysis can be found with the full version of this paper (see bmj.com). Our results were most sensitive to changes in the impact of screening on mortality. They were relatively sensitive to changes in the costs of screening but less sensitive to changes in discount rates or the cost difference between elective and emergency surgery. Figure 2 shows the probability that screening is cost effective at different levels of willingness to pay for a life year gained. At £30 000 per life year the probability for our main analysis is 0.55. The figure also shows how this probability would change with a different screening cost.

Projection of longer term cost effectiveness

Over a longer period, cost effectiveness will improve substantially: those in whom death is prevented during the first four years will continue to accumulate additional life years after this time. More such deaths are expected to be prevented after four years, and the costs of screening will increase only marginally over time. On the basis of the conservative assumptions

Table 2 Estimates of mean (SE) costs and effects to four years per patient

	Intervention (n=33 839)	Controls (n=33 961)
Costs (£):		
After adjustment for censoring	103.67 (4.41)	38.22 (3.32)
After adjustment for censoring and discounting at 6%/year	98.42 (4.15)	35.03 (3.04)
Difference in costs (95% CI), after discounting	63.39 (53.31 to 73.48)	
Effects:		
No of deaths related to abdominal aortic aneurysm	58	105
Survival time (days)	1459.41 (0.228)	1458.54 (0.271)
Survival time (days) after discounting at 1.5%/year	1394.73 (0.216)	1393.92 (0.256)
Difference in survival time in days (95% CI), after discounting	0.82 (0.16 to 1.47)	
Cost per life year gained from screening (95% CI)	28 389 (15 281 to 145 598)	

What is already known on this topic

Small trials have suggested that an ultrasound screening programme to detect abdominal aortic aneurysms in older men may be effective

There is uncertainty about the cost effectiveness of routine screening, with widely varying estimates

What this study adds

A cost effectiveness analysis of data from a large randomised trial with follow up over four years showed 47 fewer deaths and additional costs of £2.2m in the group invited to screening

The adjusted net cost per patient was £63.39 and per life year gained was £28 400

The projected cost per life year gained after 10 years was £8000, which is substantially lower than the perceived NHS threshold value

specified above, the cost effectiveness ratio at 10 years would be around £8000 per life year saved (discounting both costs and life years).

Discussion

The clinical trial and this analysis provide firm estimates of the costs and effects up to four years of screening for abdominal aortic aneurysms. The study design may have led to some small biases resulting in conservative estimates of effect [7] and cost effectiveness. Both the incremental cost and the incremental effectiveness of screening were significant, with quite narrow confidence intervals around costs. The costs of elective and emergency surgery in this study were substantially higher than suggested in previous UK studies,[2 4–6 16 17] in part reflecting the detail of analysis, the extensive samples in this study, and our inclusion of costs of any complications up to one year.

It is clear from our projection that an analysis based on results to four years only will underestimate the longer term cost effectiveness substantially. On the basis of our conservative assumptions (see methods), the projected cost effectiveness ratio at 10 years is estimated to be £8000 per life year saved. The improvement largely stems from the accumulating life years gained for those in whom death related to abdominal aortic aneurysm was prevented during the first four years of the trial. However, much more elaborate modelling and sensitivity analysis is needed to assess the considerable uncertainty around our estimate of cost effectiveness at 10 years and to provide estimates over still longer time periods.

Nevertheless, the policy conclusions are clear. The four year analysis shows a cost effectiveness ratio already at the margin of acceptability and the projection shows that this will fall considerably even at 10 years. The clinical analysis[7] and this economic analysis of the MASS trial together provide clear evidence to support the cost effectiveness of this particular form of screening in elderly men.

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1 Lindholt JS, Juul S, Fastin H, Henneberg EW. Hospital costs and benefits of screening for abdominal aortic aneurysms. Results from a randomised population screening trial. *Eur J Vasc Endovasc Surg* 2002;23:55-60.
2 Collin J. The value of screening for abdominal aortic aneurysm by ultrasound. In: Greenholgh RM, Mamaid JA, eds. *The causes and management of aneurysms*. Philadelphia, PA: Saunders, 1990:447-56.
3 Frame PS, Fryback DG, Patterson C. Screening for abdominal aortic aneurysm in men ages 60 to 80 years. *Ann Intern Med* 1993;119:411-6.
4 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;15:154-60.
5 Law MR, Morris J, Wald NJ. Screening for abdominal aortic aneurysms. *J Med Screen* 1994;1:110-6.
6 St Leger AS, Spencely M, McColum CN, Mossa M. Screening for abdominal aortic aneurysm: a computer assisted cost-utility analysis. *Eur J Vasc Endovasc Surg* 1996;11:183-90.
7 Multicentre Aneurysm Screening Study Group. The multicentre aneurysm screening study (MASS) into the effects of screening on mortality in men: a randomised controlled trial. *Lancet* 2002;360:1531-9.
8 Netten A, Rees T, Harrison G. *Units costs of health and social care*. Canterbury: Personal Social Services Research Unit, University of Kent at Canterbury, 2001.
9 Chartered Institute of Public Finance and Accountancy. *The health service financial database and comparative tool*. Croydon: Institute of Public Finance, 2000.
10 Willan AR, Lin DY. Incremental net benefit in randomised trials. *Stat Med* 2001;20:1563-74.
11 Heitjan DF. Fieller's method and net health benefits. *Health Econ* 2000;9:327-35.
12 Van Hout BA, Al MJ, Gordon GS, Rutten FF. Costs, effects and the C/E-ratios alongside a clinical trial. *Health Econ* 1994;3:309-19.
13 Raftery J. NICE: faster access to modern treatments? Analysis of guidance on health technologies. *BMJ* 2001;323:1300-3.
14 National Institute for Clinical Excellence. *Guidance for manufacturers and sponsors*. London: NICE, 2001 (Technology Appraisals Process Series No 5).
15 Kind P, Hardman G, Macran S. *UK population norms for EQ-5D*. York: University of York, 1999 (CHE Discussion Paper 172).
16 Forbes JF, Brady AR, Brown LC, Fowkes FGR, Greenhalgh RM, Powell JT, et al. Health service costs and quality of life for early elective surgery or ultrasonographic surveillance for small aortic aneurysms. *Lancet* 1998;352:1656-60.
17 Jepson RG, Forbes JF, Fowkes FGR for UK Small Aneurysm Trial Participants. Resource use and costs of elective surgery for asymptomatic abdominal aortic aneurysm. *Eur J Vasc Endovasc Surg* 1997;14:143-8.

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Endpiece

A newspaper

A newspaper is a device for making the ignorant more ignorant and the crazy crazier.

H L Mencken,
American editor, author, and critic, 1880-1951