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WHAT THIS PAPER ADDS

In the 20th century a progressive increase in the incidence of aortic aneurysm was reported in England and Wales and other developed countries. This has now changed in England and Wales and Scotland, with a rapid decline in mortality from both aortic aneurysm and abdominal aortic aneurysm (AAA), particularly in men and those <75 years of age. The decrease in mortality cannot be explained by an increasing number of elective AAA repairs (any increase being confined to those 75+ years). This suggests that epidemiological changes underlie the decreasing incidence of clinically-relevant aneurysms.

ABSTRACT

Background: Between 1951 and 1995 there was a steady increase in age-standardised deaths from all aortic aneurysms in men, from 2 to 56 per 100,000 population in England & Wales, supporting an increase in incidence. More recently, evidence from Sweden and elsewhere suggests that now the incidence of abdominal aortic aneurysm (AAA) may be declining.

Methods: National statistics for hospital admissions and deaths from AAA, after population age-standardisation, were used to investigate current trends in England & Wales and Scotland.

Results: Between 1997 and 2009 there has been a reduction in age-adjusted mortality from AAA from 40.4 to 25.7 per 100,000 population for England & Wales and from 30.1 to 20.8 per 100,000 population in Scotland. The decrease in mortality was more marked for men than women. Mortality decreased more than 2-fold in those <75 years versus 25% only in those >75 years. During this same time period the elective hospital admissions for AAA repair have only increased in the population >75 years.

Conclusions: These data suggest that the age at which clinically-relevant aneurysms present has increased by 5–10 years and that incidence of clinically-relevant AAA in men in England & Wales and Scotland is declining rapidly. The reasons for this are unclear.

Introduction

During the 20th century there was a steady increase in mortality from aortic aneurysm in England and Wales.1,2 During this time the ascertainment of abdominal aortic aneurysm (AAA) improved, with increased use of ultrasonography, but the incidence of aortic aneurysm also was considered likely to be increasing.1 During the 20th century population screening studies, using ultrasonography, have indicated that the prevalence of AAA in 65-year old men was 4%.3 When the age group 65–74 years was used, the prevalence rose to 5% in men and about one-third of this in women.4 Evidence synthesised from four randomised trials has shown the benefit of screening in avoiding deaths from AAA rupture.5 Following these findings, aneurysm-screening programmes, usually of men aged 65 years, have been implemented in several countries. These screening programmes are now reporting a much lower prevalence of AAA than was observed in the late 20th century, 1.9% in England and 1.7% in Sweden respectively.6,7

The principal risk factor for abdominal aortic aneurysms is smoking. Smoking is a much stronger risk factor for abdominal aortic aneurysm than for coronary artery disease.8 Smoking also increases the growth rate of small AAA and increases the rate of...
aneurysm rupture. As knowledge of the health hazards of smoking has increased, there has been a progressive decline in the prevalence of smoking and more recently there has been legislation outlawing smoking in confined public spaces in many developed countries. Although the prevalence of smoking in England and Wales has been declining since the early 1970s, in 1985 mortality from aortic aneurysm was still increasing rapidly.1 By 1999, the rising mortality was showing signs of levelling off.2 Now, 30–40 years after the peak prevalence of smoking, has the risk of AAA been attenuated? This, combined with increasing detection and appropriate treatment of AAA, could now be halting the mortality from AAA. Indeed recent studies from the USA, New Zealand and Australia have all shown that mortality from AAA is no longer increasing.9–11

Here, we examine recent trends in both mortality from and hospital admissions for AAA in England and Wales and Scotland. These are the clinically-relevant aneurysms: either requiring elective surgery or rupturing.

Methods
Population-based mortality

Mortality statistics for England and Wales for 1950–1973 were obtained from annual publications from the Registrar General’s Mortality Statistics. For the years 1975–2009 these were obtained from annual publications from the Office for National Statistics (ONS). Mortality statistics for Scotland 1979–2009 were requested from National Records of Scotland. England and Wales statistics obtained for the time period 1950–2009 include the codes for the underlying cause of death, using the sixth to tenth revision of the International Classification of Diseases (ICD 6–10). From 1950 to 1967 the cause corresponded to; aortic aneurysm specified as non-syphilitic and dissecting aneurysm (451); from 1968 to 1973, aortic aneurysm – non-syphilitic (441); from 1975 to 1978, aortic aneurysm – non-syphilitic (441.0), thoracic aneurysm (441.1), abdominal aneurysm (441.2), other (441.9); from 1979 to 2000, aortic aneurysm (441.0–6); and from 2001 to 2009, aortic aneurysm and dissection (I71.0–9). England and Wales and Scotland data obtained for the time period 1979–2009 include the codes for the underlying cause of death, using the ninth and tenth revision of the International Classification of Diseases (ICD9/10). In 3 randomised trials of the management of AAA12–14 the ICD code for infrarenal abdominal aortic aneurysm and aortic aneurysm of unspecified site appeared to be used interchangeably, with the proportion of unspecified site usage in trials of patients with known AAA being similar to the proportion used nationally for the same years. Therefore we used data from 4 ICD codes to investigate mortality from AAA: ruptured abdominal aortic aneurysm (441.3/I71.3), abdominal aortic aneurysm without mention of rupture (441.4/I71.4), ruptured aortic aneurysm of unspecified site (441.5/I71.8) and aortic aneurysm of unspecified site without mention of rupture (441.6/I71.9). ICD codes that were excluded are 441.0/I71.0 (dissecting aneurysm), 441.1/I71.1 (ruptured thoracic aneurysm), 441.2/I71.2 (thoracic aneurysm without mention of rupture), I71.5 (ruptured thoraco-abdominal aneurysm), I71.6 (thoraco-abdominal aneurysm without mention of rupture). The data are presented in yearly intervals; however data were unobtainable for the years 1980, 1981 and 1992. All data were stratified by gender and narrow age bands, from the age of 50 years and above.

Hospital admissions

Data for hospital admissions for England and Wales for 1989–2009 were obtained from Hospital Episode Statistics (HES) whose data years run from April to March of the following year. For Scotland the same data were obtained from National Services Scotland. The diagnoses at admission were coded using the same ninth and tenth revisions of the ICD as for mortality. Separate codes for open and endovascular procedures were not available before 2006–7. All data were stratified by gender and narrow age bands from the age of 45 years and above.

Methods of standardisation and calculation of trends in mortality and admission rates

Age and sex specific population-based mortality and hospital admissions as obtained above, were used to calculate age-standardised mortality and admission rates for men and women for each yearly interval. Mortality was standardised by total number of deaths above the age of 50 years. Admissions were standardised by total number of admissions above the age of 45 years. The discrepancy in age-standardisations is due to differences in age banding between ONS and HES. The number of deaths and number of admissions were used as the numerators and the total resident population for the corresponding age thresholds were used as the denominators to calculate deaths and admissions per 100,000 population.

Results

First, the age-standardised mortality from all aortic aneurysms (abdominal aortic aneurysm, thoracic aneurysm, aortic aneurysm of unspecified site and dissecting aneurysm) in England and Wales until 2009 was estimated, to provide data since the initial reporting to 1983.1 The significant increase observed between 1950 and 19831 continued until 1996, after which there has been a sharp fall in mortality from aortic aneurysm (Fig. 1). The age-standardised mortality in men was 2.4 in 1950, 56.4 in 1996 and 31.9 in 2009 per 100,000 population.

After restriction of ICD codes to those in use for abdominal aortic aneurysm (AAA) only, the age-standardised mortality from AAA increased steadily from 1979 to 1996 (Fig. 2). From 1997 onwards the age-standardised mortality has fallen sharply, so that by 2009 the mortality from AAA was lower than in 1979. A very similar trend in mortality has been observed in Scotland too (Fig. 2). The use of ICD9/10 codes for aortic aneurysm was similar in England and Wales and Scotland and does not explain the apparently lower mortality in Scottish men, which has been noted previously.15 Both in England and Wales and in Scotland most of the aortic aneurysm...
mortality is attributed to aneurysm rupture: summary data for England and Wales are shown in Table 1. When the population-based mortality is stratified by gender, it is clear that the recent decline in mortality from aortic aneurysm is particularly marked in men (Fig. 3).

The age-standardised elective admissions for AAA repair from 1989 to 2009 for both England and Wales and Scotland are shown, by gender; in Fig. 4 (emergency admissions for rupture also are shown in Fig. 4). Elective admissions increased rapidly in men between 1989 and 1996, but thereafter the increase in elective admissions has been modest. There have been similar, but less marked changes in women. Therefore, the rapid increase in admissions for elective aneurysm repair, coincided with the time period when mortality was increasing rapidly too. In England and Wales, elective admissions increased only from 41.4 to 44.7 per 100,000 population between 1997 and 2009, the period during which mortality declined from 40.4 to 25.7 per 100,000 population. Similar changes were observed in Scotland. Therefore, it seems unlikely that an increased rate of detection and repair of AAA alone is responsible for the marked recent decline in population-based mortality.

The age-profiles of the mortality from AAA (Fig. 5A,B) in 1997 and 2009 in England and Wales and Scotland are compared in Fig. 5 by gender (5A men, 5B women). It would appear as though in 2009, the AAA deaths have shifted, by 5–10 years, to the older population groups, with few deaths occurring below 70 years. These trends are particularly clear for men in Scotland and women in England and Wales. The age-standardised mortality for those <75 years decreased more than 2-fold between 1997 and 2009, from 18.2 to 7.6 per 100,000 population, whereas for those 75 years and over the mortality had diminished by only 25% over this time period, from 116.0 to 86.9 per 100,000 population. Therefore, the strongest decline in aneurysm deaths is in those <75 years.

The number of elective admissions for AAA repair in England and Wales, by age band, is shown in Fig. 6. Between 1997 and 2009, there was a significant reduction in admissions in the 55–64 y group (p < 0.01) and no increase in the elective admission for the 65–74 y group. The increase in elective admissions (1997–2009) appears to be attributable entirely to the significantly increased admissions and repairs in those >75 years (p < 0.001 for each group). During this same time period admissions for aneurysm rupture have declined significantly, from 18.6 to 13.5 per 100,000 population, with significant decline in all age groups, except those over 85 years (data not shown). Together, these data suggest both that aortic aneurysms are now presenting later in life and that their true incidence may be declining.

Risk factors for the development, progression and rupture of aneurysms, such as smoking, have changed with time, as has the use of cardioprotective drugs, which may attenuate the risk of aneurysm rupture, e.g. statins and ACE inhibitors, and other public health measures, as shown in Fig. 7. By 2009, even in older age groups <20% are current smokers, the control of hypertension has improved and statins are prescribed to more than one-third of the population.

Discussion

In the period 1997–2009, mortality from AAA has declined rapidly, in both England and Wales and in Scotland. There are some differences between these countries and clear differences between

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Table 1

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Figure 2. Age-standardised mortality from abdominal aortic aneurysm in England and Wales and Scotland 1979–2009. England and Wales represented by solid black line and Scotland by dotted black line. Data standardised above the age of 50 yrs for men and women for total deaths of ICD9/10 codes; (441.3/I71.3), (441.4/I71.4), (441.5/I71.8), (441.6/I71.9).
men and women, with the reduction in mortality being much greater in men than women. The percentage decrease in mortality is greatest for those <75 years, although in this age group there has been no increase in elective admissions for aneurysm repair. In those 75 years or older, there has been an increase in elective admissions for aneurysm repair and a modest decrease in mortality from AAA, which is not fully accounted for by the increase in aneurysm repairs. These observations suggest that the age at which AAA become clinically relevant has increased by 5–10 years since 1997 and that the incidence of clinically-relevant aneurysms has declined, particularly in those <75 years.

The focus of this work is on clinically-relevant aneurysms, those large enough either to be considered for aneurysm repair or to rupture. There are no parallel data for the incidence of small AAA, although there are indications, from population screening studies in England and Sweden, that the incidence of these also may have declined more than 2-fold in 65-year old men, over a similar time period. It is possible that the UK Small Aneurysm Trial, which reported in 1998 might have had a small effect to reduce the number of elective aneurysm repairs of small aneurysms (<5.5 cm diameter) in the UK but this could only account for a small reduction effected before 2000, although prolonged surveillance before surgery could have had some effect to increase the age at eventual aneurysm repair. Similarly, it is likely that the advent of endovascular repair has enabled safe aneurysm repair in the elderly population, particularly those over 80 years, a population who might have been turned down for surgery before 2000. Specific data for elective endovascular versus open repair only have been available in Hospital Episode Statistics since 2006–7. The early data...
suggest that endovascular repair may be increasing most sharply in the most elderly patient population. Since 15% or less of AAA deaths are from causes other than rupture (Table 1), an improvement in national elective mortality from 10% in 1997–2000 to the 4% reported from a selective cohort in 2009, would at best have contributed to a 10% decrease in AAA mortality. These clinical factors alone do not appear sufficient to explain the continuing sharp reduction in mortality from AAA.

The limitations of the current study include the use of administrative data-bases only, with potential limitations on the accuracy of reporting, lack of case-mix adjustment and the continuous change to ICD reporting. However since 1979 the same categories of aortic disease have been used in both ICD-9 and ICD-10. Another limitation is the focus on clinically-relevant AAA, with the exclusion of information about most small aneurysms, which are kept under surveillance. Rupture of an AAA is one of the causes of death which is often missed (in over half of cases) without autopsy. However, the rate of autopsies in England is almost unchanged between 1990 and 2010 at about 22%. This is much higher than in Scotland and could contribute to the higher rates of AAA mortality observed for men in England and Wales.22

This difference between mortality from AAA in England and Wales and Scotland has been commented upon previously and also might be attributable to the high rates of early cardiac mortality in men in Scotland. Trends for Scottish women are very similar to those for women in England and Wales and in women the reduction in mortality has been small and much less than in men (Fig. 5). The main UK population screening programme for AAA in men did not start to be rolled out until 2008–2009 and therefore cannot explain the more rapid decline in mortality in men compared with women. It is possible that older men are subject to more imaging studies of the abdomen and pelvis than women, so that the incidental detection rate is higher in men. The reduction in smoking appears to have been faster in men (Fig. 7) and older men are prescribed statins more often than older women and both of these could have contributed to the more rapid decline in mortality in men. However, although these factors may be contributory, there is no quantitative evidence to explain the faster rate of mortality decline in men than women.

The scope of this study was limited to ICD mortality codes used for known AAA but mortality from thoraco-abdominal aortic, thoracic aortic aneurysms and dissections were excluded. Similarly restricted codes were used for elective and ruptured aneurysm repair. The relevant populations for England and Wales or Scotland were used for age-standardisation. Therefore the numerical values reported for age-standardised mortality or hospital admissions reported here differ slightly from those reported previously where the definition of aortic aneurysm was broader and World Health Organisation populations were used for age-standardisation. Nevertheless, the recent decline mortality has been reported from New Zealand too. Also, there is evidence from both Australia and the USA that the age at elective aneurysm repair is increasing.9,10

The observations reported here and in other countries, such as Sweden, argue strongly for a changing epidemiology and decrease in incidence of AAA, particularly in those <75 years. Reasons for an altered epidemiology are likely to include public health campaigns to reduce smoking and air pollution and targets for management of hypertension and hyper-cholesterolaemia in the population. While such changes are of importance, our observations also have clinical relevance for the practice and organisation of vascular surgery. Aneurysm surgery is best practised in high volume centres and a reduction in caseload would mean that fewer of these were required. Increasingly, those with clinically-relevant aneurysms will be over 75 years of age and likely to have increased risk of perioperative mortality, with endovascular repair being strongly favoured in this age group. Nevertheless, complications after endovascular repair also increase with age, which is likely to increase the costs of treatment. If the age of the population at greatest risk of...
aortic aneurysm has shifted to >75 years, is 65 years too young for population screening? After all, the MASS trial has shown an increase in aneurysm ruptures in the screened group at 8 years after screening, this suggests that some aneurysms might only have developed after the age of 65 years.

The increasing age at which clinically-relevant aneurysms present and reducing the incidence in those <75 years presents new challenges for vascular surgery in developed countries.

Conflict of Interest
None.

Funding
None.

References