Abdominal aortic aneurysm disease in New Zealand: epidemiology and burden between 2002 and 2006

Nisha Nair, Caroline Shaw, Diana Sarfati, James Stanley

Abstract

Background Abdominal aortic aneurysm (AAA) rupture has a high mortality. Four randomised controlled trials indicate significant mortality benefit from population screening for AAA. There is a lack of information on the epidemiology and burden of AAA disease in New Zealand, necessary to support policy in this area.

Methods A retrospective analysis was conducted on a dataset consisting of all AAA deaths and all hospital discharges with a AAA diagnosis between 2002 and 2006. Analysis by age, sex, ethnicity, and operative status was performed.

Results On average, there were 267 elective repairs and 87 emergency repairs annually between 2002 and 2006. The operative mortality rate was 35.2% for emergency repair, and 6.7% for elective repair.

There were about 236 known AAA-related deaths annually. Ninety-four percent of AAA deaths between 2002–2006 occurred in individuals >65 years. The case fatality for females was higher than males across every age group. The standardised mortality rate in Māori was twice as high as New Zealand Europeans.

Conclusions This study provides essential information to evaluate the appropriateness and feasibility of AAA screening here. A population-based prevalence study is recommended, along with further investigation of high case fatality in females and high mortality in Māori.

Abdominal aortic aneurysms (AAAs) are present in about 5 to 10% of men aged 65 to 79 years. Generally, they expand without causing symptoms until they rupture, or, the individual dies of an unrelated cause. AAA rupture is a surgical emergency, and less than half of rupture patients reach the hospital alive. Emergency repair itself carries a high operative mortality of 30 to 65%, attributable to haemodynamic compromise, advanced age, and medical comorbidities. Overall, AAA rupture carries a mortality rate as high as 80 to 90%. In contrast, elective repair is associated with a considerably lower operative mortality, between 3 and 10%.

Population-based AAA screening programmes use abdominal ultrasound scans to detect AAAs before they rupture. Four major randomised controlled trials evaluating AAA population screening have been performed to date. Meta-analysis of these shows that AAA screening reduces AAA-related mortality by about 40% in males aged 65 to 79 years. However, issues of concern include the risk of overtreatment, the benefit-harm balance of elective repair, and health system capacity. (see companion article in this NZMJ issue for further discussion on AAA screening).

The United Kingdom began gradually implementing population screening for AAA in 2009, screening males aged 65 years. In the United States, Medicare has covered
AAA screening in male ever-smokers aged 65 to 75 and females with a family history of AAA since 2007.\(^\text{20}\) There is currently no policy for AAA screening in New Zealand, although “awareness of the research evidence for screening is high.”\(^\text{21}\)

The evidence base for AAA screening draws heavily from international studies. The relatively small body of local research has been focused mainly on in-hospital mortality from rupture, selection criteria for emergency repair, clinical presentation of rupture, risk factors, and endovascular repair analysis. There is a lack of recent national-level information on overall epidemiology of AAA events and deaths, both in and out of hospital. This information is essential to inform any policy around AAA screening in New Zealand.

Accordingly, the objective of this study is to describe the burden of AAA disease in New Zealand by AAA events, AAA-related deaths, and vascular surgical workload. It also aims to describe AAA events and deaths by age, sex, ethnicity, and operative status. This is the first of two papers; the second evaluates the evidence for population screening for AAA in New Zealand against screening criteria.

**Methodology**

**Study population**—Records with ICD-10 codes for AAA [I71.3 ‘abdominal aortic aneurysm, ruptured’ and I71.4 ‘abdominal aortic aneurysm, without mention of rupture’]\(^\text{22}\) were extracted from two national databases, the Mortality Collection and the National Minimum Dataset (NMDS).\(^\text{23}\) Collectively, these datasets contained all deaths between 2002 and 2006 for which the *underlying cause of death* was AAA, and all publicly funded hospital discharges from 2002 to 2006 with any diagnosis of AAA. From these datasets, three populations were defined: AAA Events, AAA Deaths, and AAA Alive Discharges (Figure 1).

In order to identify these three populations, firstly, hospital discharges that involved a AAA operation were identified from the NMDS dataset (using ICD-10 operation codes for emergency and elective repair). These were then separated into AAA Operative Deaths (within 30 days of procedure) and AAA Alive Discharges using the event end type codes. All AAA Operative Deaths were then matched against the Mortality Collection, and duplicates identified.

The non-duplicates were assumed to be AAA Non-Operative Deaths, as AAA rupture without surgery carries a 100% mortality.\(^\text{a}\)

**Variables**—The analysis was limited to the AAA Events and AAA Deaths populations. These were then analysed by age (<55 yrs; 55-64 yrs; 65-74 yrs; 75-84 yrs; 85+ yrs); sex; ethnicity (prioritised ethnicity fields were provided by the Ministry of Health Information Directorate as per Ministry of Health ethnicity data protocols and categorized as European, Māori, Pacific Island, Asian, and Other),\(^\text{24,25}\) and operative status (elective repair, emergency repair after rupture, or no surgery after rupture).

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\(^{a}\) In a very small number of patients with AAA rupture, the surrounding tissue seals off the bleeding and the patient remains haemodynamically stable. This is termed chronic AAA rupture and patients can survive for a prolonged length of time. However, risk of free rupture is very high and prompt surgical repair is clinically indicated. For the purposes of this paper we have assumed a 100% mortality as this small group is unlikely to alter the findings.
Figure 1. Populations identified from datasets used

<table>
<thead>
<tr>
<th>AAA Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>All events (deaths and admissions) where the predominant reason for the event is AAA. This comprises</td>
</tr>
<tr>
<td>- nonoperative deaths (whether in or out of hospital)</td>
</tr>
<tr>
<td>- operative deaths (whether in elective or emergency repair)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AAA Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Non-operative deaths</td>
</tr>
<tr>
<td>- Operative deaths associated with elective repair</td>
</tr>
<tr>
<td>- Operative deaths associated with emergency repair</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AAA Alive Discharges</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Alive discharges after elective repair</td>
</tr>
<tr>
<td>- Alive discharges after emergency repair</td>
</tr>
</tbody>
</table>

**Statistical methods**—The tables show frequency counts and proportions for AAA Events and AAA Deaths. Operative mortality (AAA operative deaths/AAA operative events x100), case fatality rates (AAA deaths/AAA events X 100), and age and sex standardised mortality and event ratios have been calculated. The reference population for standardised ratios was the 2006 Census Usually Resident Population (CURP),

apart from the prioritised ethnicity analysis (which utilised 2001 census data as prioritized ethnicity data by age and sex for the 2006 census were not available at the time of analysis).

Statistical analysis was performed using SAS version 9.1 software. Confidence intervals for case fatality rates were calculated using OpenEpi version 2.3 software.

Confidence intervals for indirectly standardised event and mortality ratios were calculated using the formulae from Rothman, Green & Lash.

Prevalence and incidence of AAAs could not be calculated because it was not possible to identify individuals with AAAs too small for elective repair, those who do not qualify for/refuse elective repair, and those with intact but undiagnosed AAAs.

**Ethical approval**—Ethical approval was obtained from the Multi-Region Ethics Committee. The Ngāi Tahu Research Consultation Committee was also consulted before project initiation.

**Results**

Table 1 is an overview of AAA events and deaths, by operative status. There were 1182 AAA-related deaths between 2002 and 2006, equating to about 236 deaths per year. Almost 80% of these deaths were in patients after rupture who did not undergo surgery, and 13% and 7.5% in those not surviving emergency repair and elective repair, respectively.

There were 1774 AAA repairs between 2002 and 2006; about 25% of these were emergency repairs and 75% elective repairs. This equates to about 87 emergency
repairs and 267 elective repairs each year. The 30-day operative mortality rate was 35.2% for emergency repair, and 6.7% for elective repair.

Table 1. AAA events, AAA deaths, and operative mortality between 2002 and 2006

<table>
<thead>
<tr>
<th>Operative status</th>
<th>AAA events Number (%)</th>
<th>AAA deaths Number (%)</th>
<th>Operative mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rupture (No surgery)</td>
<td>926† (34.3%)</td>
<td>939† (79.4%)</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Rupture (Emergency surgery)</td>
<td>438 (16.2%)</td>
<td>154 (13.0%)</td>
<td>35.2%</td>
</tr>
<tr>
<td>Elective repair</td>
<td>1336 (49.5%)</td>
<td>89 (7.5%)</td>
<td>6.7%</td>
</tr>
<tr>
<td>Total</td>
<td>2700 (100%)</td>
<td>1182 (100%)*</td>
<td></td>
</tr>
</tbody>
</table>

* Due to rounding, percentages may not add up to exactly 100%.
† This table shows a discrepancy of 13 individuals between ‘deaths’ and ‘events’. This is due to 13 people who underwent repair but died beyond the 30-day mark. From the AAA events perspective, they were counted as repairs. However, these 13 did not fulfill definition of an ‘operative death’ (i.e. within 30 days of operation) and so by default had to be included in the non-operative group.

Table 2 shows AAA events, deaths, case fatality, and operative mortality rates by age group. About 89% of all AAA events and almost 94% of all AAA deaths occurred in individuals aged ≥65 years.

The overall emergency repair operative mortality rate was 35.2%, and the elective repair mortality rate was 6.7%. Predictably, operative mortality rates increased with increasing age. Operative mortality in individuals aged >85 years was about 58% for emergency repair, and almost 12% for elective repair.

Table 2. AAA events, deaths, case fatality and operative mortality by age group between 2002 and 2006

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>AAA events Number (%)</th>
<th>AAA deaths Number (%)</th>
<th>Case fatality Percent (95% CI)</th>
<th>30-day operative mortality rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Emergency repair</td>
</tr>
<tr>
<td>≥85</td>
<td>350 (13.0%)</td>
<td>303 (25.6%)</td>
<td>86.6% (82.6–90.0)</td>
<td>58.3%</td>
</tr>
<tr>
<td>75–84</td>
<td>1180 (43.7%)</td>
<td>548 (46.4%)</td>
<td>46.5% (43.6–49.3)</td>
<td>40.0%</td>
</tr>
<tr>
<td>65–74</td>
<td>864 (32.0%)</td>
<td>255 (21.6%)</td>
<td>29.5% (26.5–32.7)</td>
<td>28.8%</td>
</tr>
<tr>
<td>55–64</td>
<td>278 (10.3%)</td>
<td>69 (5.8%)</td>
<td>24.8% (19.9–30.3)</td>
<td>22.9%</td>
</tr>
<tr>
<td>&lt;55</td>
<td>28 (1.0%)</td>
<td>7 (0.6%)</td>
<td>25% (10.7–44.9)</td>
<td>66.7%</td>
</tr>
<tr>
<td>Total</td>
<td>2700 (100%)</td>
<td>1182 (100%)*</td>
<td>43.8% (41.9–45.7)</td>
<td>35.2%</td>
</tr>
</tbody>
</table>

Table 3 shows AAA events by operative status in each age group. There is a pattern of reduced surgical intervention (both elective and emergency repair) with increasing age. Elective repairs predominated in younger age groups, and non-operative events predominated in older age groups. In individuals aged ≥85 years, non-operative events constituted almost 81% of all AAA events. Reduced surgical intervention at older ages is expected given that advanced age is a predictor of poor outcome.32,33
Table 3. AAA events by age group and operative status between 2002 and 2006

<table>
<thead>
<tr>
<th>Age group</th>
<th>No surgery after rupture/ non-operative</th>
<th>Emergency repair after rupture</th>
<th>Elective repair</th>
<th>AAA events</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number (% of total events by age range)§</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;85 years</td>
<td>283 (80.9%)</td>
<td>24 (6.9%)</td>
<td>43 (12.3%)</td>
<td>350 (100%)</td>
</tr>
<tr>
<td>75–84 years</td>
<td>410 (34.8%)</td>
<td>200 (17.0%)</td>
<td>570 (48.3%)</td>
<td>1180 (100%)</td>
</tr>
<tr>
<td>65–74 years</td>
<td>179 (20.7%)</td>
<td>163 (18.9%)</td>
<td>522 (60.4%)</td>
<td>864 (100%)</td>
</tr>
<tr>
<td>55–64 years</td>
<td>51 (18.4%)</td>
<td>48 (17.3%)</td>
<td>179 (64.4%)</td>
<td>278 (100%)</td>
</tr>
<tr>
<td>&lt;55 years*</td>
<td>3 (10.7%)</td>
<td>3 (10.7%)</td>
<td>22 (78.6%)</td>
<td>28 (100%)</td>
</tr>
<tr>
<td>Total</td>
<td>926</td>
<td>438</td>
<td>1336</td>
<td>2700</td>
</tr>
</tbody>
</table>

* Small event numbers in this age group, should be interpreted with caution
§ Due to rounding, percentages may not add up to exactly 100%.

Table 4 shows AAA events and deaths by sex and ethnicity, along with age and sex standardised event and mortality ratios.

Table 4. AAA events and AAA deaths by sex and ethnicity between 2002 and 2006, with age and sex standardised event and mortality ratios

<table>
<thead>
<tr>
<th>Sex</th>
<th>AAA events (n and %)</th>
<th>AAA deaths (n and %)</th>
<th>Standardised event ratio (indirect standardisation for age and sex)* †† (ratio and 95%CI)</th>
<th>Standardised mortality ratio (indirect standardisation for age and sex)* †† (ratio and 95%CI)</th>
<th>Case fatality rate (% and 95%CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>1949</td>
<td>760</td>
<td>100 (ref)</td>
<td>100 (ref)</td>
<td>39.0% (36.9–41.2)</td>
</tr>
<tr>
<td>Female</td>
<td>751</td>
<td>422</td>
<td>23.3 (21.7–25.0)</td>
<td>29.7 (27.0–32.7)</td>
<td>56.2% (52.6–59.8)</td>
</tr>
<tr>
<td>Total</td>
<td>2700</td>
<td>1182</td>
<td>100%</td>
<td>100%</td>
<td>39.0% (36.9–41.2)</td>
</tr>
<tr>
<td>Ethnicity:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NZ European</td>
<td>2411</td>
<td>1066</td>
<td>100 (ref)</td>
<td>100 (ref)</td>
<td>151.2 (129.6–176.4)</td>
</tr>
<tr>
<td>Māori</td>
<td>162</td>
<td>82</td>
<td>151.2 (129.6–176.4)</td>
<td>217.9 (175.5–270.6)</td>
<td>221.9 (179.9–237.0)</td>
</tr>
<tr>
<td>Pacific</td>
<td>34</td>
<td>20</td>
<td>76.3 (54.5–106.7)</td>
<td>123.9 (79.9–192.0)</td>
<td>61.4 (35.6–105.7)</td>
</tr>
<tr>
<td>Asian</td>
<td>27</td>
<td>13</td>
<td>46.3 (31.8–67.6)</td>
<td>61.4 (35.6–105.7)</td>
<td>53.2 (7.5–378.0)</td>
</tr>
<tr>
<td>Other</td>
<td>20</td>
<td>1</td>
<td>412.5 (266.1–639.4)</td>
<td>412.5 (266.1–639.4)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2654#</td>
<td>1182</td>
<td>100%</td>
<td>100%</td>
<td>56.2% (52.6–59.8)</td>
</tr>
</tbody>
</table>

* reference population for indirect standardisation in sex analysis was 2006 CURP males.
† reference population for indirect standardisation in ethnicity analysis was 2001 CURP for each ethnicity
# 46 events were missing ethnicity data.

About 72% of AAA events, and 64% of AAA deaths occurred in males. After indirect standardisation, the observed AAA event rate in females was about 23% that of males. The death rate in females was about 30% of that in males. The disparity between sexes in AAA death rates is narrower than in AAA event rates. One explanation for this is the higher case fatality in females (56%) compared to males (39%).

In other analyses not shown here, higher case fatality in females was evident in each age group, and females also presented at older ages for rupture and elective repair.
Almost 91% of AAA events between 2002 and 2006 occurred in New Zealand Europeans, 6% in Māori, and about 1% in each of Pacific, Asian and ‘Other’. After age and sex standardisation, Māori had a AAA event rate about 1.5 times higher than New Zealand Europeans. However, the standardised mortality rate of Māori was about double that of New Zealand Europeans. In other analyses not shown here, Māori also presented at younger ages for rupture and elective repair.

The results suggest that Pacific people have somewhat lower event rates but higher mortality, although neither are statistically significant. Both event and mortality ratios suggest a lower disease burden among Asian people, but considerably higher burden among those in ‘Other’ ethnic groups.

Discussion

Between 2002 and 2006, there were on average 236 diagnosed AAA-related deaths per year. Almost 94% of these occurred in individuals aged ≥ 65 years. Almost 80% of AAA deaths occurred in a non-operative setting, 13% associated with emergency repair, and 7.5% associated with elective repair. There was an average of 267 elective repairs and 87 emergency repairs per year, with associated operative mortality rates of 6.7% and 35.2% respectively. Although over 70% of AAA events occurred in males, females had higher case fatality across every age group. Similarly, although over 90% of AAA events and deaths occurred in New Zealand Europeans, Māori had a standardised mortality rate twice as high as New Zealand Europeans.

The total number of AAA repairs here is similar to the 1868 repairs reported by Rossaak et al between 1993 and 1997. Any change in the relative proportions of elective and emergency repair between 1993-97 and 2002-2006 cannot be commented on, as Rossaak et al used three categories of AAA repair (emergency, urgent, and elective) as compared to the two categories used here. The emergency repair operative mortality rate of 35.2% is similar to that reported by Grant et al (37.8%) and slightly lower than the 40% reported in a 2007 NZVASC audit. It compares favourably with international estimates, which range from 30 to 65%. The relatively low emergency repair mortality rate in New Zealand may reflect surgical expertise, good postoperative care, a stricter selection policy for emergency repair, or some combination thereof. The elective repair mortality rate of 6.7% is slightly higher than the 4% reported in the 2007 NZVASC audit, and is in line with international estimates of 3 to 10%. Based on this study, the risk of dying was five times higher with emergency repair than with elective repair.

This analysis identified three populations that appear to be particularly vulnerable. Firstly, individuals ≥ 65 years account for the vast majority of AAA deaths, and case fatality is particularly high in individuals ≥ 85 years. This is not surprising given AAA prevalence is estimated to increase by 6% per decade after 65 years. Advanced age is also associated with lower rates of surgical intervention and significantly higher operative mortality rates from both elective and emergency repair. However, less incidental/opportunistic detection of AAAs in this age group may also play a role, along with a higher likelihood of declining repair even when offered.

Secondly, although females have lower AAA prevalence and mortality than males, they have higher case fatality across every age group. This is consistent with both national and international evidence. Possible reasons include higher risks of
rupture, lower rates of emergency repair being offered, and higher operative mortality from emergency repair. Internationally, concerns have been raised about possible gender bias in diagnosis of or selection for surgical treatment in AAA.\textsuperscript{43}

Thirdly, Māori have higher AAA event and mortality rates as compared with New Zealand Europeans, and also present with the condition at a younger age. This is consistent with Rossaak et al.’s findings when analysing AAA admissions in New Zealand between 1993 and 1997. Additionally, more emergency procedures and a higher proportion of admissions for rupture was also reported.\textsuperscript{34} The disproportionate burden of AAA disease in Māori is likely to be multifactorial. Higher prevalence of smoking in Māori is a risk factor for both AAA development and AAA rupture.\textsuperscript{44} Higher prevalence of high blood pressure,\textsuperscript{45} smoking,\textsuperscript{44} diabetes, and obesity\textsuperscript{46} may also increase mortality from emergency and elective repair. Māori also have poorer access to primary care, which may mean less opportunity for AAA detection. Additionally, there is increasing evidence (particularly from studies in cardiovascular disease management) that secondary and tertiary services may serve Māori less well than non- Māori.\textsuperscript{47-49}

Strengths and limitations—The major strength of this study is that it combines mortality and hospital datasets to provide a more comprehensive picture of AAA burden. Previous studies have largely utilised hospital data, and this is a highly selected group given less than half of rupture patients reach the hospital alive. The wider view afforded by this study is essential in planning a population-based intervention.

Coding inaccuracies within the datasets used is a potential limitation of this study. This was minimized by using AAA operation codes to identify individuals with AAA-related diagnoses, rather than more subjective AAA diagnosis codes. Individuals admitted with AAA who did not undergo repair would not have had operation codes. However, these individuals would have been represented in the mortality dataset due to the fatal nature of this condition.

The analysis of AAA events and deaths by age, sex, and ethnicity provide valuable information on the demographics of individuals with AAA. However, in certain populations (< 55 years and some ethnicities), numbers were small and results should be interpreted with caution. This analysis also was not able to differentiate between endovascular and open repair. Trends in endovascular repair have significant implications for decisions relating to population-based screening. Finally, undercounting of Māori should always be considered. Studies have shown that there is no net undercount of Māori on mortality records from this period, but hospitalisation data may be less reliable.\textsuperscript{50}

The study population was not able to include individuals with AAAs too small for elective repair, individuals who do not qualify for/refuse elective repair, and individuals with undiagnosed but intact AAAs. Thus, this study cannot reliably comment on AAA prevalence or incidence. It is also likely that the figure of 236 AAA-related deaths per year may be an underestimate. While deaths from elective or emergency repair are reliable, the same cannot be said for non-operative AAA deaths. Firstly, there are significant inaccuracies in death certification, particularly in the elderly. In particular, in an elderly individual with an undiagnosed AAA, there is a tendency for sudden death to be attributed to a more common condition like coronary
artery disease. Secondly, low autopsy rates (particularly in the elderly) compound the risk of misclassifying the cause of death. The only way of overcoming this knowledge gap is a population prevalence study.

**Implications for policy**—This study describes AAA events, deaths, and vascular surgical workload over a five-year period. Alongside other local studies, it provides a baseline for assessing the appropriateness and feasibility of a AAA screening programme in New Zealand. However, a population-based prevalence study would provide a more complete picture of AAA burden. Additionally, the drivers of high event and mortality rates in Māori, and high case fatality in females warrant further investigation. An understanding of existing inequalities in AAA disease is vital if a potential AAA screening programme is to avoid exacerbating them. Knowledge of vulnerable populations and existing service gaps is imperative in formulating AAA screening policy, identifying target areas for implementation, and guiding quality assurance measures.

**Competing interests:** Caroline Shaw is a member of the National Screening Advisory Committee which provides independent advice to the Director General of Health on screening issues.

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**References:**

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