The costs of elective and emergency abdominal aortic aneurysm repair: a comparative single centre study

Kevin Niall Peek, Manar Khashram, J Elisabeth Wells, Justin A Roake

ABSTRACT

AIM: Population-based screening for abdominal aortic aneurysms (AAA) is being considered in New Zealand. However, there is a lack of data to support its cost effectiveness in this country. The aim of this study was to compare the hospital costs of AAA repair in emergency and elective cases over a 3-year period in a single centre in New Zealand.

METHODS: A retrospective observational analysis of consecutive patients undergoing elective and emergency AAA repair during the study period (January 2009 to December 2011) was performed.

RESULTS: A total of 169 AAA repairs were performed during the study period, of which 114 (67%) were open repairs. Sixty-four of these were open elective AAA repairs, 40 were open ruptured repairs, and 10 were open symptomatic repairs. The mean inpatient cost was $38,804 for open ruptured AAA repair and $28,019 for open elective repair, a difference of $10,785 (95%CI: $249 to $21,321; p=.045). The costs of blood products and laboratory investigations were significantly greater in the ruptured group than the elective. There was no significant difference in length of hospital admission between the groups.

CONCLUSIONS: This study demonstrates that ruptured AAA repairs are more expensive than elective AAA repairs, despite no difference in length of hospital stay. The estimated inpatient costs documented in this study for each type of repair can be used for cost-effectiveness analysis in New Zealand. A screening program that reduces the incidence of surgery for ruptured AAA could decrease the average inpatient cost of AAA repairs.

Abdominal aortic aneurysms (AAA) are a significant cause of mortality in New Zealand accounting for about 236 deaths per year, of which 80% are attributed to ruptures.[1] Recent international studies suggest that the prevalence of AAA is about 2% in men aged 65.[2,3] The natural history of AAA is a progressive increase in diameter to the point of rupture. The risk of aneurysm rupture increases with increasing diameter.

Approximately, 30% of patients with a ruptured AAA die pre-hospital. Of those undergoing repair, the mortality rate is approximately 35%. There is an overall mortality rate of up to 85%.[4] However, when detected prior to rupture, they can be treated electively by open or endovascular methods, with open surgical procedures carrying a mortality of 3–10%.[5]

Four randomised controlled trials summarised by a meta-analysis showed that ultrasound AAA screening was associated with a significant reduction of AAA-related mortality in men aged 65–79 years.[5] There are six countries that offer screening or are in the process of developing screening programs for AAA.[6] Currently, no such programme exists in New Zealand, although consideration has been given to initiating one. Nair and colleagues have documented the burden of AAA in New Zealand from 2002 until 2006.[1] An average of 267 AAA were repaired electively, and a further 87 repaired as an emergency each year. Mortality rates for elective and emergency

NZMJ 22 April 2016, Vol 129 No 1433
ISSN 1175-8716
www.nzma.org.nz/journal

repairs were 6.7% and 35.2% respectively. Almost all AAA deaths occurred in people aged over 65 years.[1] Sandiford et al report declining incidence and mortality rates of AAA in New Zealand since 1991, which may be attributable to a reduction in smoking rates and the use of statins to control serum cholesterol.[7] In New Zealand, the prevalence of AAA in the population is still unknown, but in a selected population undergoing CT colonography for gastrointestinal symptoms, a prevalence of 9.1 % in men 65–75 years old was observed. [8] This highlights the burden of AAA disease in New Zealand and the importance of an AAA screening program.

Cost analysis comparing open aneurysm repair (OAR) and endovascular aneurysm repair (EVAR) has been assessed in randomised controlled trials.[9,10] However, inpatient costs of AAA repair in the contemporary clinical setting have not been assessed in New Zealand.[11] The aim of this study was to compare the hospital costs of AAA repair in emergency and elective cases over a 3-year period in a tertiary referral vascular centre.

Methods

This was a retrospective, observational analysis of consecutive patients undergoing elective and emergency AAA repair, from 1 January 2009 until 31 December 2011, in a single New Zealand centre.

The exclusion criteria was: isolated iliac aneurysms with open or endovascular methods; non-aneurysmal aortic surgery for occlusive disease; complex fenestrated and branched endovascular aneurysm repair (EVAR) grafts; or treatment for infected aortic grafts or mycotic aneurysms.

The unit's protocol for all patients undergoing open AAA repair was to stay in ICU for one night minimum. There is no routine ICU or HDU for EVAR patients. The majority of elective cases were admitted into hospital on the same day of surgery and EVAR patients receive their first imaging surveillance (ultrasound) at 6 weeks post-operatively, unless there were any clinical concerns.

Patients were identified using a prospectively-collected vascular database and the hospital's decision support tool. Patients' clinical presentations were defined into three groups: ruptured AAA repair; symptomatic but not ruptured AAA repair; or elective AAA repair. Information for each patient was extracted from the vascular database, including demographics, vascular risk factors and length of stay (LOS). The hospital's decision clinical coding data was used to extract the cost of each admission. The costing system uses several techniques used to derive each inpatient costs. Inventoried items (eg, theatre materials, grafts, blood products) are recorded for each admission and are assigned a value based on the cost of the product to the DHB. There is a similar process with hospital services (eg, labs, ECHO, radiology). Nursing and doctor's hours are assigned a value based on the time spent in a particular location of for the patient (eg, theatre, ICU, ward) which reflect the differences in staff numbers and salary for each. The time of other health care providers is also logged and includes physiotherapy, social work, phlebotomy, and inpatient specialist referral. The components used to determine the cost of each admission were examined and grouped into the following categories for analysis: pre-hospital (including pre-admission and air ambulance costs), operation, intensive care, blood products, laboratory and other.

Four separate analyses were performed:

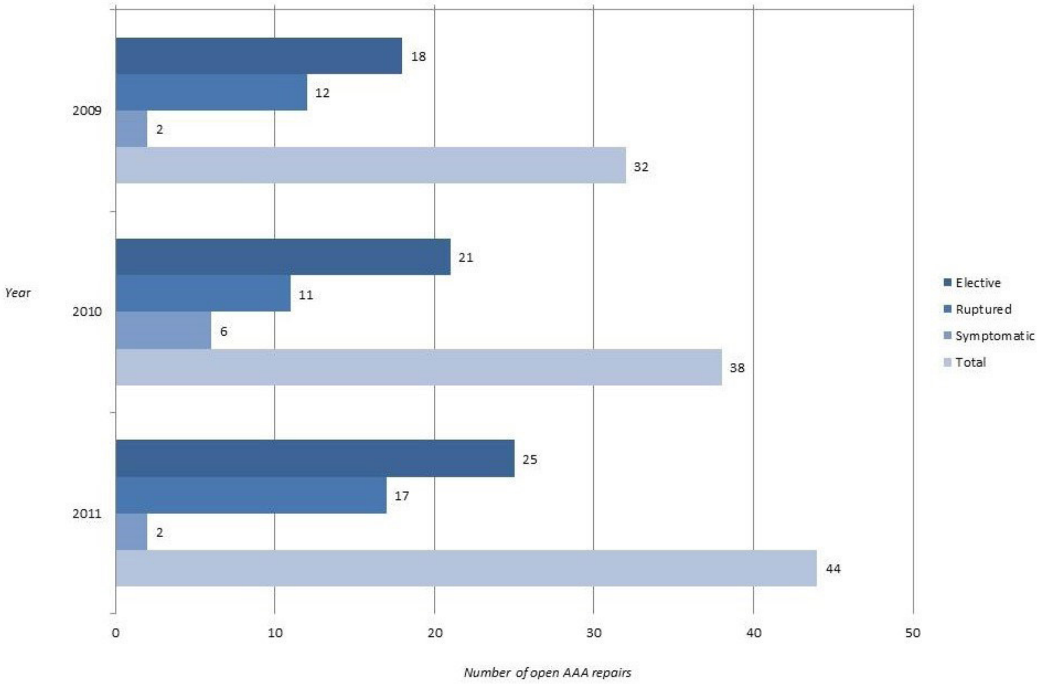
1. The difference in costs of OAR between elective and ruptured groups was examined. EVAR patients were not included in the primary analysis as it was hypothesised that an unequal distribution of EVAR, with a high stent graft cost, in the elective group would affect the comparability of the groups. In addition, the use of EVAR for treating ruptured AAA has not been widely adopted at our institution.
2. OAR were examined, excluding patients who died in less than 4 days, as it was hypothesised that early mortality would lead to a lower difference of cost between the groups.
3. All patients presentations who had OAR and EVAR were analysed.
4. OAR was compared to EVAR in the elective cases only to provide context for the other analyses and to provide data for future modelling.

Table 1: Summary of demographics and risk factors for open AAA repairs.

	Elective	Ruptured	Symptomatic
n=	64	40	10
Median age (range)	73 (57–86)	77 (49–86)	74 (62–82)
Males (%)	46 (72)	34 (85)	8 (80)
Diabetes (%)	3 (4)	4 (10)	0
Smoking history (%)	37 (58)	17 (42)	6 (60)
Hypertension (%)	34 (53)	18 (45)	7 (70)
Ischaemic heart disease (%)	20 (31)	6 (15)	2 (20)
On statin therapy (%)	35 (55)	13 (33)	3 (30)
On antiplatelet therapy (%)	37 (61)	13 (33)	5 (50)
Median ASA† (range)	3 (2–4)	3 (2–5)	3 (2–3)
30-day mortality (%)	0	11 (28)	0

†American Society of Anesthesiologists physical status classification system

Figure 1: The number of open AAA repairs performed in each year of the study period stratified by the indication for surgery.



NZMJ 22 April 2016, Vol 129 No 1433
ISSN 1175-8716 © NZMA
www.nzma.org.nz/journal

Table 2: Costs and length of stay of open AAA repair in the primary analysis.

Group	Variable	Mean (SD)	Median (Q1–Q3)
Elective (n=64)	Length of stay (days)	9 (5)	8 (6–11)
	Total cost	$28,019 (16,306)	$24,628 ($21,012–$29,306)
	Pre-hospital	$149 (200)	$159 ($0–$198)
	Operation	$9,763 (2,880)	$8,413 ($6,568–$9,618)
	ICU	$6,500 (10817)	$4,487 ($3,905–$5,113)
	Blood products	$373 (954)	$49 ($0–$546)
	Laboratory costs	$402 (337)	$327 ($237–$459)
	Ward costs	$9,498 (3988)	$9,053 ($7,157–$11,790)
	Other	$1,335 (2053)	$666 ($358–$1,225)
Ruptured (n=40)	Length of stay (days)	10 (8)	9 (4–16)
	Total cost	$38,804 (30,620)	$31,895 ($24,691–$40,7301)
	Pre-hospital	$241 (1,497)	$0 ($0–$0) †
	Operation	$9,682 (5,061)	$9,115 ($6,960–$11,346)
	ICU	$13,250 (21,693)	$7,868 ($3,857–$14,166)
	Blood products	$4,404 (6,069)	$2,328 ($1,195–$4,772)
	Laboratory costs	$731 (591)	$549 ($422–$884)
	Ward costs	$8,170 (7,431)	$7,400 ($610–$13,229)
	Other	$2,327 (3559)	$1,248 ($562–$2,298)
Symptomatic (n=10)	Length of stay (days)	12 (9)	8 (7–15)
	Total cost	$33, 743 (19,351)	$25,891 ($21,973–$36,439)
	Pre- hospital	$432 (869)	$0 ($0–$179)
	Operation	$8,740 (1,414)	$9,083 ($8,315–$9,774)
	ICU	$8,108 (7,079)	$4,679 ($3,975–$8,854)
	Blood products	$905 (1,026)	$820 ($43–$1,225)
	Laboratory costs	$666 (558)	$508 ($306–$764)
	Ward costs	$13,050 (10,378)	$7,673 ($6,938–$17,071)
	Other	$1,842 (1,612)	$1,344 ($617–$2,013)

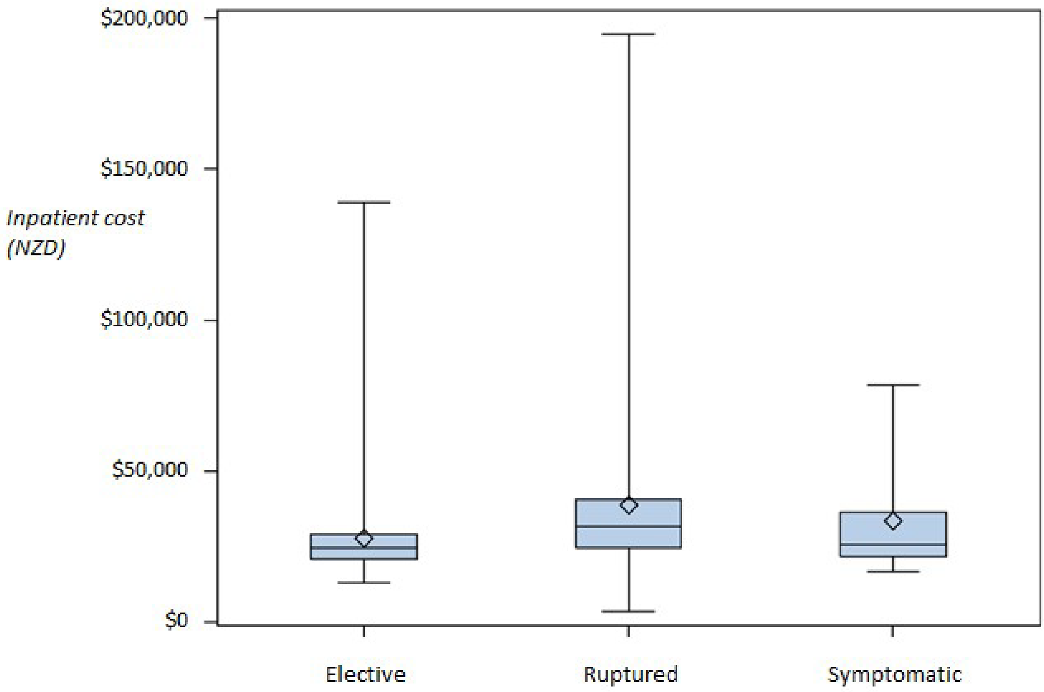
†3 patients

Analyses were carried out using SAS/STAT 12.1 software. All t-tests used the Satterthwaite approximation for unequal variances. Statistical significance was set at $p<0.05$. Although cost distributions were inspected and found to be skewed with long tails of high values, analyses focused on mean costs rather than the medians, as these are what are relevant to health care planners.[12]

Results

A total of 169 AAA were repaired during the study period. This consisted of 117 (69.2%) elective repairs (64 OAR and 53 EVAR), 42 (24.9%) ruptured repairs (40 OAR and 2 EVAR), and 10 (5.9%) symptomatic repairs (all OAR). The total number of ruptured AAA presenting to the hospital

Figure 2: Box plots demonstrating the distribution of inpatient costs in each study group.



during this period was 89, of which 47 (53%) were managed non-operatively, either dying before reaching the operating theatre or after having decided not to undergo operation. Demographics and risk factors for each group is summarised in Table 1. The median age for the elective, ruptured, and symptomatic groups was 73, 77 and 74 years, respectively. All three groups consisted primarily of male patients. The elective group had a higher proportion of patients with ischaemic heart disease, who were receiving statin and antiplatelet therapy compared to the other groups. The symptomatic group had the highest proportion of patients with a recorded history of smoking and hypertension. There was no 30-day mortality in the elective or symptomatic groups. The 30-day mortality of the ruptured aneurysms repaired was 11 out of 42 (26.2%).

Thirteen out of the 117 (11%) elective patients, and 7 out of the 42 (17%) of ruptured patients, were discharged to a rehabilitation facility. The median length of stay (LOS) in rehabilitation for the elective and rupture group was 8 and 12 days respectively.

Primary analysis: Costs of open AAA repairs between elective and ruptured groups

114 open AAA were repaired during the study period. Of those, 64 were elective repairs, 40 were ruptures and 10 were symptomatic repairs. Figure 1 demonstrates the number of open repairs performed annually stratified by the indication for surgery.

The costs and LOS amongst the groups included in the primary analysis is presented in Table 2. The mean cost per patient in the open elective group was $28,019. In the open ruptured group it was $38,804, and for the open symptomatic group it was $33,743. The distribution of the total cost per group is demonstrated by the box plots in Figure 2. The mean LOS was 9 days for elective, 10 days for rupture, and 12 days for symptomatic admissions. The most significant categories contributing to the total costs amongst the three groups were operation, ward and ICU costs, with overall means of $9,644, $9,343 and $9,009, respectively. The median time from start of anaesthetic until leaving operating theatre for the elective, rupture group and the symptomatic groups was 265, 205 and 224 minutes respectively.

Table 3 shows the statistical comparison between the open rupture and elective groups. There was a significant difference between the mean inpatient cost of open ruptured AAA repair and open elective AAA repair of $10,785 (95%CI: $249, $21,321; p=0.045). The cost of blood products was $4,031 greater (95%CI: $2,077, $5,985; p=0.0002), and the cost of laboratory

Table 3: Statistical comparison of length of stay and costs between open ruptured and elective groups.

	Mean cost ruptured (SD) [n=40]	Mean cost elective (SD) [n=64]	Mean Difference	95% CI for difference
Length of stay (days)	10 (8)	9 (5)	1	-2, 4
Total cost	$38,804 (30,620)	$28,019 (16,306)	$10,785*	$249, $21,321
Pre- hospital	$241 (1,497)	$149 (200)	$92	-$389, $573
Operation	$9,682 (5,061)	$9,763 (2,880)	-$81	-$1,839, $1,677
ICU	$13,250 (21,693)	$6,500 (10,817)	$6,750	-$650, $14,150
Blood products	$4,404 (6,069)	$373 (954)	$4,031***	$2,077, $5,985
Laboratory costs	$731 (591)	$402 (337)	$329**	$123, $534
Ward costs	$8,170 (7,431)	$9,498 (3,988)	-$1,328	-$3,888, $1,231
Other	$2,327 (3,559)	$1,335 (2,053)	$992	-$247, $2,231

*p <0.05, **p <0.01, ***p <0.001

Table 4: Statistical comparison of length of stay and costs between open rupture and elective groups with early mortality (<4 days) excluded.

	Mean cost ruptured (SD) [n=31]	Mean cost elective (SD) [n=64]	Mean Difference	95% CI for difference
Length of stay (days)	12 (7)	9 (5)	3*	.5, 6
Episode cost	$44,182 (32,582)	$28,019 (16,306)	$16,163*	$3,612, $28,714
Pre- hospital	$310 (1,700)	$149 (200)	$162	-$463. $787
Operation	$9,999 (5,546)	$9,763 (2,880)	$236	-$1,907, $2,380
ICU	$15,906 (23,938)	$6,500 (10,817)	$9,406*	$266, $18,546
Blood products	$3,743 (1,543)	$373 (954)	$3,370**	$1,159 $5,581
Laboratory costs	$849 (623)	$402 (337)	$447***	$208, $686
Ward costs	$10,454 (7,918)	$9,498 (3,988)	$956	-$1,747, $3,661
Other	$2,918 (3,851)	$1,335 (2,053)	$1,583*	$90, $3,076

*p <0.05, **p <0.01, ***p <0.001

investigations was $329 greater (95%CI: $123, $534; p=0.002) in the ruptured group than the elective group. There was no difference in pre-hospital, operation, ICU, ward or 'other' costs between the groups. There was no significant difference in LOS between the two groups.

Costs of open AAA repairs between elective and ruptured groups, excluding early (<4 day) mortality

Of the 40 patients with ruptured AAA who had a repair, nine died within four days. The mean difference of costs between ruptured and elective groups with early mortality excluded is presented in Table 4. In this analysis, there was a significant mean difference of $16,163 (95%CI: $3,612, $28,714; p=0.01) between open ruptured AAA repair and open elective AAA repair. ICU, blood product, laboratory and 'other' costs were significantly higher in the ruptured group, while pre-hospital, operation and ward costs were not different.

Costs of all AAA repairs between elective and ruptured groups, including EVAR

There were 53 elective and two rupture EVARs. The mean total inpatient cost of elective EVAR was $31,023 per patient. The mean cost of the aortic stent graft for those

Table 5: Statistical comparison of length of stay and costs between rupture and elective groups including EVAR.

	Mean cost ruptured (SD) [n=42]	Mean cost elective (SD) [n=117]	Mean Difference	95% CI for difference
Length of stay (days)	10 (8)	7 (5)	3*	0.5, 6
Total cost	$38,590 (29,880)	$29,380 (13,641)	$9,210	-$404, $18,825
Pre-hospital	$242 (697)	$129 (162)	$113	-$344, $568
Operation	$10,400 (5,912)	$17,537 (10,321)	-$7,137	-$9,750, $4,524
ICU	$12,619 (21,349)	$3,590 (8,602)	$9,029	-$2,206, $15,850
Blood products	$4,197 (5,992)	$260 (743)	$3,937***	$2,065, $5,809
Laboratory costs	$706 (586)	$291 (308)	$415***	$224, $606
Ward costs	$7,963 (7,307)	$6,191 (4,810)	$1,772	-$657, $4,202
Other	$2,460 (3,558)	$1,388 (1,885)	$1,072	-$75, $2,219

*p <0.05, **p <0.01, ***p <0.001

Table 6: Summary of demographics and risk factors for elective and rupture groups including EVAR.

	Elective	Ruptured
n=	117	42
Median age (range)	74 (57–86)	75 (49–86)
Males (%)	88 (75)	35 (83)
Diabetes (%)	11 (9)	4 (10)
Smoking history (%)	72 (62)	17 (40)
Hypertension (%)	73 (63)	20 (48)
Ischaemic heart disease (%)	39 (33)	8 (19)
On statin therapy (%)	61 (52)	14 (33)
On antiplatelet therapy (%)	67 (57)	14 (33)
Median ASA† (range)	3 (2–4)	3 (2–5)
30 day mortality (%)	0 (0)	11 (26)

who underwent EVAR was $14,765. Table 5 shows the results of a cost analysis of all AAA repairs, including EVAR, during the study period. This analysis included 117 elective AAA and 42 ruptured AAA. The demographics and risk factors relevant to this analysis are summarised in Table 6. The mean total cost in the elective group was $29,380 and $38,590 in the ruptured group. There was a trend towards a lower mean cost in the elective group, but the mean difference of $9,210 was not statistically significant (95%CI: -$404, $18,825; p=0.06). Blood products and laboratory costs were significantly higher in the ruptured group. The mean length of stay was 3 days shorter in the elective group than in the rupture group (95%CI: 0.5, 6; p=0.02). When comparing the elective group including EVAR to the elective group excluding EVAR, there appears to be a higher operation cost and a lower ICU cost.

Costs of AAA repair between EVAR elective and open elective groups

Table 7 shows the difference in mean cost between the 53 patients who had EVAR and the 64 patients who had open procedures as an elective case. The EVAR group had a 5 day (95%CI: -7, -4; p<0.0001) shorter

Table 7: Statistical comparison of length of stay and costs between EVAR elective and open elective groups.

	Mean cost EVAR elective (SD) [n=53]	Mean cost open elective (SD) [n=64]	Mean Difference	95% CI for difference
Length of stay (days)	4 (3)	9 (5)	-5***	-7, -4
Total cost	$31,023 (9,380)	$28,019 (16,306)	$3,004	-$1,777, $7,786
Pre- hospital	$107 (134)	$149 (200)	-$42	-$98, $14
Operation	$26,926 (5,061)	$9,763 (2,880)	$17,163***	$14,861, $19,463
ICU	$77 (231)	$6,500 (10,817)	-$6,423***	-$9129, -$3,717
Blood products	$125 (308)	$373 (954)	-$248	-$499, $4
Laboratory costs	$147 (189)	$402 (337)	-$255***	-$354, -$156
Ward costs	$2,199 (1,630)	$9,498 (3,988)	-$7,299***	-$8,358, -$6,213
Other	$1,453 (1,675)	$1,335 (2,053)	$118	-$564, $801

*p <0.05, **p <0.01, ***p <0.001

length of hospital stay than open AAA repair. However, there was no difference in total inpatient cost. The mean difference in operation cost was in the EVAR group, significantly higher than in the open group at $17,163 (95%CI: $14,861, $19,463; p<.0001), while the mean difference in ICU and ward costs were significantly lower.

Discussion

In this study, we observed a higher mean of inpatient costs of rupture compared to elective OAR despite no difference in LOS. The significantly more expensive costs were those of blood products and laboratory tests. By excluding early mortality, a larger difference was observed. When EVAR were included in the analysis a trend, but not a significant difference, was observed. As documented in other studies, the cost of the EVAR procedure was significantly more expensive than an OAR operation but the overall inpatient mean elective cost was similar between both EVAR and OAR.[9]

One of the important factors to weigh in the decision about initiating a screening program for AAA in New Zealand is cost effectiveness. AAA ruptures have declined following screening programs in other parts of the world because patients with large aneurysms would have been referred for surgical consideration, and small AAA would undergo regular surveillance.[5,13] A screening program that reduces the incidence of ruptured AAA would decrease the average individual inpatient cost of AAA repairs. However, it is still necessary to determine the other expenses involved in screening, including the cost of providing the test, the cost of surveillance of detected small aneurysms and the cost of repairing a larger number of AAA electively. Further research could also determine the cost per quality-adjusted life year gained after AAA repair.

In 2000, Patel et al determined that the cost of repairing ruptured AAA was acceptable compared to no intervention.[14] There are five historical published papers comparing hospital costs of ruptured and elective AAA repairs.[15-19] Three of these papers were from the US,[15,16,18] one from Australia,[17] and one from Canada.[19] Table 8 compares the presented data to each of the studies. The results of each study examined show that ruptured AAA repair have a higher mean hospital cost than elective AAA repair, and this difference reached statistical significance in all cases during the last 35 years. The current study is similar in methodology to two of the American studies, Roher et al[15] and Pasch et al.[16] The other three papers did not include consecutive patients from each group for comparison.[17-19] The current study has the second largest group and highest, when EVAR included. In addition, this study was the first to include symptomatic, but not ruptured, emergency AAA repairs and provides cost data of this group. Study dates of the previously published papers ranged from the 1970s

Table 8: Presented data from the current study and five comparable papers.

	Rohrer et al[15]	Pasch et al[16]	Bagia et al[17]	Ascher et al[18]	Chew et al[19]	Current study
Country	USA	USA	Australia	USA	Canada	New Zealand
Method	Retrospective, Consecutive patients	Retrospective, Consecutive patients	Retrospective, Randomly-selected patients, stratified by age	Retrospective, Matched controls	Retrospective, Consecutive ruptures, random controls	Retrospective, consecutive patients
N=	30	129	40	20	89	114 (169†)
Ruptured	14	20	20	10	41	40 (42†)
			10 <80 yrs,			
			10 >80 yrs			
Elective	16	109	20	10	48	64 (117†)
			10 <80 yrs,			Symptomatic = 10 (10†)
			10 >80 yrs			
Study dates	1977–1987	1980–1981	1987–1994	1993–1995	1997–1998	2009–2011
Mean cost rupture	35,500	18,223	<80 = 33,600; >80= 37,347	126,305	18,899	38,804(38,590†)
Mean cost elective	26,000	10,114	<80=8,081; >80=10,305	33,165	12,324	28,019 (29,380†)
Significant difference?	Yes	Yes	Yes	n/a	Yes	Yes (No)

†Information in brackets including EVAR

until the 1990s, so the current paper provides more recent cost information. The current study also provides cost figures from New Zealand and is therefore useful when considering a national screening program. The results of the paper concur with the results from Asher et al,[18] and Chew et al,[19] that blood product costs contribute significantly to the total costs difference, however, Asher et al[18] also found that ICU and ward costs were higher in the ruptured group.

In New Zealand, the proportion of elective AAA treated with EVAR remains at 55–60% (Australasian Vascular Audit). This figure is different from Australia and the US, where 70–80% of AAA are managed with EVAR.[20] The influence of an AAA screening program in New Zealand is unlikely to change this proportion for several reasons. First, on average the ratio of treatment modality (OAR vs EVAR) has remained fairly constant in the last 5 years. Secondly, there is no overall difference in patient survival following AAA repair with either method, and decision to choose the most appropriate modality remains clinician and patient based. Finally, 5-year data from the UK AAA screening programme has shown that the 46.2% of patients had an EVAR and the remaining patients had an OAR (personal communication).

Limitations to the study included the large variability in the costs which were examined. It is suspected that for this reason a significant difference in ICU cost was not observed in the primary analysis, and that ICU cost was in fact the main driver of the cost difference. This study did not show a significant difference between groups when the analysis was preformed including EVAR, but it is believed that there is a convincing trend towards a lower inpatient cost in the elective setting which is also driven by lower ICU cost. Additionally, it is expected that patients with ruptured aneurysms would require more post-operative rehabilitation or further community district costs. These costs were not collected in this analysis. Other limitations include the relatively small number of patients studied and the retrospective nature of the study. It is worth noting that patient and family, community care and associated rehabilitation costs were not included in this study. The costs generated are likely to slightly underestimate the overall costs of AAA repair.

In conclusion, OAR cost more when performed in an emergency setting than when done electively. Potential cost savings in prevention of AAA ruptures and minimising associated costs in treating rupture AAA can be directed into an AAA screening strategy. The estimated inpatient costs documented in this study for each type of repair can be used for cost-effectiveness analysis in New Zealand.

Competing interests:
Nil
Acknowledgments:
Chris Hoar, Business Manager, Medical & Surgical Division, Christchurch Public Hospital; Keith Todd, Service Manager - Vascular & Cardiothoracic, Medical /Surgical Division, Canterbury District Health Board.
Author information:
Kevin Niall Peek, Canterbury District Health Board, Christchurch; Manar Khashram, Vascular Surgery Trainee, Department of Vascular Endovascular and Transplant Surgery, Christchurch Hospital, Christchurch; J Elisabeth Wells, Biostatistics and Computational Biology, Department of Population Health, University of Otago, Christchurch; Justin A Roake, Vascular Surgeon, Department of Vascular Endovascular and Transplant Surgery, Christchurch Hospital, Christchurch.
Corresponding author:
Manar Khashram, Department of Vascular Endovascular and Transplant Surgery, Christchurch Hospital, Private Bag 4710, Christchurch.
manar.khashram@gmail.com
URL:
www.nzma.org.nz/journal/read-the-journal/all-issues/2010-2019/2016/vol-129-no-1433-22-april-2016/6868

REFERENCES:

1. Nair N, Shaw C, Sarfati D, Stanley J. Abdominal aortic aneurysm disease in New Zealand: epidemiology and burden between 2002 and 2006. N Z Med J. 2012; 125: 10-20.
2. Svensjö S, Björck M, Gürtelschmid M, et al. Low prevalence of abdominal aortic aneurysm among 65-year-old Swedish men indicates a change in the epidemiology of the disease. Circulation. 2011; 124: 1118-23.
3. Davis M, Harris M, Earnshaw J. Implementation of the National Health Service Abdominal Aortic Aneurysm Screening Program in England. J Vasc Surg. 2013; 57: 1440-5.
4. Reimerink JJ, van der Laan MJ, Koelemay MJ, et al. Systematic review and meta-analysis of population-based mortality from ruptured abdominal aortic aneurysm in Wales. Br J Surg. 2013; 100: 1405-13.
5. Cosford PA, Leng GC. Screening for abdominal aortic aneurysm. Cochrane Database Syst Rev. 2007; (2): CD002945.
6. Stather PW, Dattani N, Bown MJ, et al. International Variations in AAA Screening. Eur J Vasc Endovasc Surg. 2013; 45: 231-4.
7. Sandiford P, Mosquera D, Bramley D. Trends in incidence and mortality from abdominal aortic aneurysm in New Zealand. Br J Surg. 2011; 98(5): 645-51.
8. Khashram M, Jones GT, Roake JA. Prevalence of Abdominal Aortic Aneurysm (AAA) in a Population Undergoing CT Colonography in Canterbury, New Zealand. Eur J Vasc Endovasc Surg. 2015; 50 (2):199-205.
9. Epstein D, Sculpher MJ, Powell JT, et al. Long-term cost-effectiveness analysis of endovascular versus open repair for abdominal aortic aneurysm based on four randomized clinical trials. Br J Surg. 2014; 101(6):623-31.
10. Brown LC, Powell JT, Thompson SG, et al. The UK EndoVascular Aneurysm Repair (EVAR) trials: randomised trials of EVAR versus standard therapy. Health Technol Assess. 2012;16(9):1-218.
11. Nair N, Sarfati D, Shaw C. Population screening for abdominal aortic aneurysm: evaluating the evidence against screening criteria. N Z Med J. 2012; 125: 72-83.

12. Lumley T, Diehr PH, Emerson S, Chen, L. The importance of the normality assumption in large public health data sets. Annu Rev Public Health. 2002; 23: 151-69.
13. Darwood R, Earnshaw JJ, Turton G, et al. Twenty-year review of abdominal aortic aneurysm screening in men in the county of Gloucestershire, United Kingdom. J Vasc Surg. 2012; 56: 8-13.
14. Patel ST, Korn P, Haser PB, et al. The cost-effectiveness of repairing ruptured abdominal aortic aneurysms. J Vasc Surg. 2000; 32: 247-57.
15. Rohrer MJ, Cutler BS, Wheeler HB. Long-term survival and quality of life following ruptured abdominal aortic aneurysm. Arch Surg. 1988; 123: 1213-7.
16. Pasch AR, Ricotta JJ, May AG, et al. Abdominal aortic aneurysm: the case for elective resection. Circulation. 1984; 70: I1-4.
17. Bagia JS, Robinson D, Kennedy M, et al. The cost of elective and emergency repair of AAA in patients under and over the age of 80. ANZ J Surg. 1999; 69: 651-4.
18. Ascher E, Scheinman M, DePippo P, Yorkovich W. Ruptured versus elective abdominal aortic aneurysm repair: outcome and cost. Ann Vasc Surg. 1999; 13: 613-7.
19. Chew HF, You CK, Brown MG, et al. Mortality, morbidity, and costs of ruptured and elective abdominal aortic aneurysm repairs in Nova Scotia, Canada. Ann Vasc Surg. 2003; 17: 171-9.
20. Dua A, Kuy S, Lee CJ, et al. Epidemiology of aortic aneurysm repair in the United States from 2000 to 2010. J Vasc Surg 2014; 59 (6) 1512-7.