Mortality after open aortic aneurysm surgery by Australasian surgeons trained in the endovascular era

Running title: Aortic surgery outcomes in the endovascular era

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1 Figure, 5 Tables

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Introduction. Reduced exposure of trainees to open repair (OR) of abdominal aortic aneurysm (AAA) during training has been considered detrimental to outcome. Australasian experience is examined.

Methods. The Australasian Vascular Audit (AVA) was interrogated for AAA procedures between 1/1/2010 and 31/12/2014. Surgeons completing training before 2006 (Group 1) were compared with those attaining their qualification subsequently (Group 2). The Australian Institute of Health and Welfare (AIHW) database was also interrogated to confirm the trends over time of open and endovascular repair (EVAR) since 2000. Actual exposure to OR and EVAR of AAA by trainees from 2010-2014 was also extracted.

Results. 146 surgeons in Group 1 performed 3049 OR compared with 997 for the 66 surgeons in group 2. Overall mortality for group 1 was 9.8% and for group 2, 15% ($P < .0001$). However, proportionately more ruptured AAA were treated in group 2 (31.5%) compared to group 1 (21.6%), ($P < .0001$). There was a slightly higher mortality in group 2 for ruptured but not intact aneurysm repair. Logistic regression analysis did not show consultant group to be a significant variable in the model. EVAR was performed in 7409 patients during the study period; group 1 had a 1.5% mortality compared with 1.6% for group 2 ($P .76$). AIHW data showed a trend of increasing EVAR with time. Considerable variation in OR exposure by trainees exists.

Conclusion. Reduced exposure to OR by younger trainees did not significantly affect surgical outcome when compared with those surgeons trained in an earlier period.

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Introduction

Vascular surgery has evolved from a specialty associated with major open operations to one with an increased focus on endovascular therapy for common vascular conditions, where feasible. Improved patient outcome has been the desired goal. Training of vascular surgeons has had to adapt to this change. Ever since the incorporation of endovascular aneurysm repair (EVAR) into routine practise there have been concerns that reduced exposure to open procedures during training may adversely affect patient outcomes. Abdominal Aortic aneurysm (AAA) repair is particularly relevant because skill in the performance of this demanding open operation is required, particularly for those with juxta renal aneurysms or aneurysms that are not suitable for current endovascular methods.

This study examines the mortality rate for AAA repair by Australasian surgeons trained more recently in the endovascular era, compared with that for more senior vascular surgeons trained in an earlier period as recorded in the Australasian Vascular Audit administered by the Australian and New Zealand Society for Vascular Surgery.

Methods

The Australasian Vascular Audit (AVA) is a web based audit system established in 2010¹. It is compulsory for ongoing membership of the ANZSVS but is available for non-members who wish to audit their outcomes. Mortality after aortic procedures (open and endovascular) is one of the outcomes of four groups audited. Mortality rates for AAA repair were examined by interrogating the AVA database. AAA patients were extracted for the period 1/1/2010 to 31/12/2014. Surgeons completing their training by obtaining their vascular fellowship prior to 2006 ("older consultant" - group 1) were compared with those attaining their qualification between 2006 and 2013 ("younger consultant" - group 2). 2006 was the earliest year available in the ANZSVS database for this purpose. In keeping

with the Quality Privileged status of the AVA they were identified only by their login number by the general manager of the Australian and New Zealand Society for Vascular Surgery (ANZSVS) to ensure confidentiality. Mortality at discharge was determined for all AAA procedures (open and endovascular), including intact and ruptured AAA after data cleaning.

The Australian Institute of Health and Welfare (AIHW) database was interrogated by procedure code to ascertain the trend for numbers of Open and Endovascular repairs of AAA for the periods 2000-2001, 2004-2005 and 2013-2014 to provide an idea of the relative frequency of open surgery in Australia². Actual exposure to open and endovascular repair of AAA by trainees from 2010-2014 was obtained by interrogating the AVA and examining workload by selecting some of the largest hospital(s) by Australian state and country and filtering the data by primary surgeon; “Fellow/Trainee 1” was chosen as this is the category usually selected by trainees for the rotation.

The Fisher exact test reporting two-sided P values was used to calculate the significance of differences of demographic and morphologic variables between the 2 groups and logistic regression analysis was performed on the open repair cases to assess the significance of the consultant group in the mortality model. Stata 13.1 (StataCorp. 2013. Stata Statistical Software: Release 13. College Station, TX: StataCorp LP) and StatsDirect (StatsDirect Statistical Software StatsDirect Ltd, UK) statistical software was used. Assessment of the significance of the “new consultant” and other variables was assessed by requiring a significance of $< P 0.05$ for retention in the model. Comparison of the area under the Receiver Operating Curve (AUC) with and without retention of the “younger consultant” variable was also performed using the `roccomp` command in Stata. Multilevel logistic regression analysis was performed to account for hospital level random effects, which produced a risk-adjusted model for construction of a funnel plot to assess if there were any outliers in either group³. This was obtained by using the `melogit` and `funnelcompar` commands in Stata and the funnel plot was restricted to surgeons that had performed 10 or more procedures.

Results

There were 146 surgeons in group 1 and 66 in group 2. Group 1 performed 3049 open AAA repairs compared with 997 for group 2. Group 1 had a range of procedures per surgeon from 1-99 (median 15, mean 21, SD 18.6) and for group 2 the range was from 1-65 procedures per surgeon (median 14, mean 15.3, SD 12.7). Overall mortality for group 1 was 299/3049, 9.8% and for group 2, 151/997, 15% ($P < .0001$). However, as shown in Table I there was a significantly higher percentage of ruptured AAA treated in group 2 (314/997, 31.5%) compared to group 1 (658/3049, 21.6%), $P < .0001$. When these AAA were analysed separately, there was no difference in mortality between the 2 groups for intact aneurysms, $P = .31$ but there was a difference for ruptured AAA surgical mortality with group 2 having a mortality of 121/314, 38.5% compared with 214/658, 32.5% for group 1, $P = .002$ (Table 1). When analysing the difference in suprarenal location and clamping site between the two groups in both the intact and ruptured subsets, the only difference was a lower incidence of intact suprarenal AAA in group 2 with $P = .016$ (Table 2). There were no differences in age, ischaemic heart disease, diabetes, or gender between the groups but there was a higher incidence of hypertension in group 2 (83.5% v 79.7% ($P = .008$)). The classification by the surgeon as a para-or juxta-renal AAA was extracted from the free text field as well; this showed that this only just reached statistical significance with 99 (3.2%) of group 1 and 46 (4.6%) of group 2 being thus classified ($P = .049$). There was no difference between the groups when separated by intact and ruptured AAA as shown in Table 2. Multivariate logistic regression analysis revealed that the younger consultant variable did not reach statistical significance at $P < 0.05$ in the model (Table 3) which also shows those variables found to be significant predictors of death following AAA repair. After dropping the non-significant variables, comparison of the AUC when the “younger consultant” variable was dropped (model 1) showed that there was no difference when compared with the model where it was retained (model 2) $\text{Chi}^2 = 0.12$, P

= 0.73, Figure S1, confirming that it was not a significant contributor to the model. The model displayed excellent discrimination and calibration. Having a consultant as the assistant did not show this to be a significant variable despite occurring more frequently in group 1 (4.3%) than in group 2 (2.8%) with $P = .035$ on univariate analysis.

The multilevel model showed that it was significantly different from the ordinary logistic regression model ($P = .002$). The risk-adjusted funnel plot produced by the multilevel regression in surgeons that had performed 10 or more OR revealed that there were no outliers that reached the 99% “alarm” confidence interval line in either group (Figure 1).

Endovascular repair was performed in 7409 patients during the 4 year study period; group 1 had a 1.5% (81/5417) mortality compared with 1.6% (32/1992) for group 2 ($P = .76$). The ratio of EVAR: open repair for group 1 was 1.7:1 and for group 2, 2:1. The range of number of EVAR was 1-157 (mean 37) for group 1 and 1-108 (mean 30) for group 2. When the AIHW data was examined by extracting operations by procedure code, it is apparent that the percentage of EVAR is increasing with time; 28% in 2000-2001, 46% in 2004-2015 and 76% in 2013-2014 (Table 4). When trainee exposure in the period 2010-2014 is examined, it is clear that there is considerable variation by year of training and hospital. Overall, 61% of recorded cases are endovascular over the combined 4 year period and in many units there are 3 or fewer open repairs performed per year (Table 5).

Discussion

In 2001, two eminent United Kingdom vascular surgeons described endovascular treatment of AAA as a failed experiment⁴. With time, this statement has proven to be wrong. In 2011, using Medicare data in the US, Sachs reported that the use of EVAR for intact AAA rose from 0 in 1995 to 25,192 (78% of repairs) by 2008, while open repairs decreased from 23,968 to 7190 cases, representing a

70% decrease in volume⁵. As with other reports, the present paper has documented that endovascular repair of AAA has become the preferred method of treatment in Australasia where feasible and is associated with improved short term outcomes. However, not all AAA are suitable for EVAR, either due to anatomic criteria (usually adequacy of the proximal neck of the aneurysm) or availability of equipment or personnel in the event of acute presentation. Operative skills required for EVAR are quite different to those required for conventional open surgery. As with other new surgical technology, concern has been expressed that with increased uptake of newer techniques in selected patients, surgical trainees and young surgeons would not have adequate exposure or experience with the more traditional surgical techniques for those not suitable for the newer technique or technology.

Correlation between specialty-specific training and outcome after AAA surgery has been established. Between 1992 and 1996 in Ontario the risk-adjusted mortality rate for open AAA repair by Canadian-boarded vascular surgeons was 3.5% versus 6.2% for general surgeons (P .003)⁶. Further, in a study of 13,415 open AAA repairs in Florida between 1992 and 1996, surgeons with certification for added qualifications in vascular surgery had a 24% lower risk of death or major complications (P .009)⁷. High surgeon-specific case volumes have been shown to correlate with lower mortality for intact AAA repair irrespective of institutional volume⁸. This workload concern was also expressed early in the endovascular era but there were conflicting reports; in 2001, Arko et al from Stanford showed that their overall workload of AAA interventions increased after the implementation of an EVAR program⁹. They found at this early stage of the endovascular revolution that open repair rate remained constant but increasingly complex, while endovascular repairs performed increased substantially. In the following year, Sternbergh et al reported from New Orleans that junior trainees had reduced exposure to open surgery despite an increase in overall AAA interventions¹⁰. Both of these reports emphasize the large caseload exposure to AAA repairs that trainees received in these institutions in the early endovascular era compared to those reported in this paper. In the USA the minimum number

of cases of EVAR and OR required during training of vascular surgeons has been stipulated at 20 and 30 respectively¹¹.

An interesting variation of this theme was published by Modrall et al, who showed that the surgeon's volume of all open vascular cases rather than operation-specific open aortic volume correlated better with outcomes of open aortic surgery independent of patient and hospital characteristics¹². This implied that surgical exposure to all open surgery could confer operation-specific outcome improvement. It should be noted that in Australasia, there has been a move away from absolute numbers of cases required to be performed during vascular training to a competency based system, however examination of Table 5 shows that trainees will be exposed to sufficient numbers, in view of the requirement that they rotate annually to different units in Australasia.

This paper may help to allay fears of adverse outcomes with more junior surgeons as short term outcomes in Australasia do not seem to be affected by surgeon seniority. We have also shown that younger surgeons seem to intervene on more ruptured AAA with a slightly higher mortality rate (38.5%) than their more senior colleagues (32.5%). Despite univariate analysis showing a difference in favour of group 1, risk-adjustment using logistic regression analysis has shown that there is no difference between the two groups in terms of mortality rate after OR because ruptured AAA is the most significant variable in the model. There is not a higher incidence of juxtarenal AAA, suprarenal AAA or clamping in the ruptured category to explain the higher mortality in group 2 on univariate analysis but both of the latter two are significant variables in the combined logistic regression model. Overall there were slightly more juxtarenal AAA treated by the younger surgeons, which is further encouraging confirmation of technical competence in this group.

Unfortunately, despite repeated attempts to include all procedures in the AVA the capture rate for open aortic surgery is 66% in Australia, however validation has confirmed that accuracy of data entry is excellent¹³. Thus some AAA interventions performed in Australasia will not have been included in

this audit and is a weakness in this study as there is a potential for bias. The attainment of complete participation remains a goal of the Society.

Conclusion

This study shows that vascular surgical training in open aortic aneurysm repair in Australia and New Zealand has not been significantly impaired by the advent of endovascular techniques. This is despite fewer open procedures being undertaken with the passage of time. The training rotations occur in institutions with varying proportion of open and endovascular repairs for AAA, which seem to provide sufficient exposure of trainees to both methods of treatment to produce satisfactory outcomes.

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Group 1 (n =146) Group 2 (n = 66) P (Fisher Exact test)

J Surg 2014, **84**; 624-7.

Legend for Figures

Figure 1. Funnel plot for mortality after open AAA repair (10+ cases per surgeon)

List of supporting information

Figure S1. Comparison of area under the Receiver Operating Curve for two models; with and without consultant variable

Total AAA	3049	997	
Mortality AAA (%)	(299)9.8%	(151)15%	<0.0001*
Percent ruptured AAA	(658) 21.6%	(314) 31.5%	<0.0001*
Mortality Intact AAA	(85/2391) 3.6%	(30/683) 4.4%	0.31
Mortality Ruptured AAA	(214/658) 32.5%	(121/314) 38.5%	0.002*
Suprarenal clamp-intact	(487/2391) 20%	(150/682) 22%	0.36
Suprarenal clamp-ruptured	(233/658) 35.4%	(129/314) 41%	0.09
Suprarenal AAA-intact	(125/2391) 5.2%	(21/682) 3.1%	0.016*
Suprarenal AAA-ruptured	(38/658) 5.8%	(24/314) 7.6%	0.27

Table 1. Open Aortic Aneurysm surgery in older vs younger vascular surgeons

* P< 0.05(2-sided)

Table 2. Univariate analysis of variables in the 2 groups

IHD- Ischaemic heart disease, AAA- Abdominal aortic aneurysm, Juxta- Juxtarenal

	Group 1 (3,049)	Group 2 (997)	P- Fisher exact test
Age 80 +	645(21%)	205(21%)	0.72
IHD	1406(46%)	467(47%)	0.69
Diabetes	345(11%)	127(13%)	0.23
Female	572(19%)	191(19%)	0.78
Hypertension	2433(80%)	832(84%)	0.008*
Juxtarenal AAA	99(3.2%)	46(4.6%)	0.049*
Juxta- Intact AAA	84(2.7%)	37(3.7%)	0.12
Juxta-Ruptured AAA	15(0.5%)	9(0.9%)	0.16

*P <0.05(2-sided)

Table 3. Variables analysed in logistic regression model

† Not significant (dropped from model)

<u>Parameter</u>	<u>Odds Ratio</u>	<u>(95% Confidence interval)</u>	<u>P value</u>
Female	1.67372	(1.249441 to 2.242074)	P = 0.0006
Age>80	2.505641	(1.935757 to 3.243298)	P < 0.0001
Ischaemic heart disease	1.319256	(1.028119 to 1.692834)	P = 0.0294
Diabetes	1.616129	(1.150143 to 2.270911)	P = 0.0057
Hypertension	1.442994	(1.035096 to 2.011632)	P = 0.0305
Current Smoker	1.030569	(0.764038 to 1.390078)	P = 0.8437†
Creatinine> 150mMol/L	1.333193	(0.964258 to 1.843286)	P = 0.0819†
Younger Consultant	1.215576	(0.940099 to 1.571775)	P = 0.1365†
Consultant Assisting	1.691243	(0.943662 to 3.03107)	P = 0.0775†
Ruptured	5.661523	(3.821319 to 8.3879)	P < 0.0001
Emergency	1.432194	(0.940356 to 2.181282)	P = 0.0942†
Suprarenal Clamp	1.686749	(1.306994 to 2.176846)	P < 0.0001
Suprarenal AAA	1.882748	(1.212838 to 2.922683)	P = 0.0048
Blood Loss 1-2L	1.579881	(1.098244 to 2.272739)	P = 0.0137
Blood Loss 2-3L	2.540545	(1.712789 to 3.768341)	P < 0.0001
Blood Loss 3-4L	3.040935	(1.908889 to 4.844329)	P < 0.0001
Blood Loss >4L	8.877935	(6.045258 to 13.037945)	P < 0.0001

Table 4. Percentage open and endovascular AAA repair in Australia over 2 decades (AIHW data)

AAA Abdominal Aortic Aneurysm

AIHW Australian Institute of Health and Welfare

	Open repair	Endovascular repair	% Open	% Endovascular
2000-2001	2168	865	72%	28%
2004-2005	1734	1452	54%	46%
2013-2014	753	2405	24%	76%

Table 5. Individual Trainee totals by year for Open and (Endovascular) Aortic surgery at selected Australasian Hospitals

‡ No Trainee

VIC Victoria, QLD Queensland, WA Western Australia, NSW New South Wales, SA South Australia, NZ New Zealand

Hospital	2010	2011	2012	2013	2014	Total
1(VIC)	1(10)	6(7)	3(24)	3(21)	7(14)	20(76)
2(VIC)	8(9)	5(14)	10(7)	13(13)	5(16)	41(59)
3(VIC)	4(8)	1(14)	4(9)	4(24)	6(23)	19(78)
4(VIC)	10(5)	8(15)	9(11)	15(12)	14(18)	46(51)
5(VIC)	9(6)	2(1)	3(1)	7(4)	15(5)	36(17)
6(QLD)	3(11)	8(16)	3(1)	3(12)	13(14)	30(54)
7(QLD)	9(8)	7(3)	3(6)	4(7)	3(3)	26(27)
8(WA)	2(6)	1(1)	1(1)	2(11)	2(25)	8(26)
9(NSW)	0(9)	0(8)	1(17)	‡	0(6)	
10(NSW)	‡	0(7)	1(7)	1(12)	10(16)	
11(SA)	8(1)	6(0)	2(0)	5(4)	2(5)	23(10)
12(NZ)	2(0)	1(7)	4(11)	2(12)	15(19)	24(49)
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Figure 1.tif

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