From the Society for Clinical Vascular Surgery

Age stratified, perioperative, and one-year mortality after abdominal aortic aneurysm repair: A statewide experience

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Objective: **The purpose of this study was to determine the in-hospital, 30-day, and 365-day mortality for the open repair of abdominal aortic aneurysms (AAAs), when stratified by age, in the general population. Age stratification could provide clinicians with information more applicable to an individual patient than overall mortality figures.**

Methods: **In a retrospective analysis, data were obtained from the California Office of Statewide Health Planning and Development (OSHPD) for the years 1995 to 1999. Out-of-hospital mortality was determined via linkage to the state death registry. All patients undergoing AAA repair as coded by International Classification of Diseases, 9th Revision (ICD-9) procedure code 38.44 and diagnosis codes 441.4 (intact) and 441.3/441.5 (ruptured) in California were identified. Patients <50 years of age were excluded. We determined in-hospital, 30-day, and 365-day mortality, and stratified our findings by patient age. Multivariate logistic regression was used to determine predictors of mortality in the intact and ruptured AAA cohorts.**

Results: **We identified 12,406 patients (9,778 intact, 2,628 ruptured). Mean patient age was 72.4 ± 7.2 years (intact) and 73.9 ± 8.2 (ruptured). Men comprised 80.9% of patients, and 90.8% of patients were white. Overall, intact AAA patient mortality was 3.8% in-hospital, 4% at 30 days, and 8.5% at 365 days. There was a steep increase in mortality with increasing age, such that 365-day mortality increased from 2.9% for patients 51 to 60 years old to 15% for patients 81 to 90 years old. Mortality from day 31 to 365 was greater than both in-hospital and 30-day mortality for all but the youngest intact AAA patients. Perioperative (in-hospital and 30-day) mortality for ruptured cases was 45%, and mortality at 1 year was 54%.**

Conclusions: **There is continued mortality after the open repair of AAAs during postoperative days 31 to 365 that, for many patients, is greater than the perioperative death rate. This mortality increases dramatically with age for both intact and ruptured AAA repair. (J Vasc Surg 2006;43:224-9.)**

Abdominal aortic aneurysm (AAA) repair is a procedure performed primarily to prolong life by preventing eventual aneurysm rupture. As such, the mortality associated with the operation is of prime consideration. Traditional 30-day postoperative reporting suggests that mortality is <2% to 6.5% in institutional and trial-based studies. Figures of >8% are reported in administrative database reviews of more generalized segments of the population.[1,2] These figures can aid the clinician in planning and informing patients about the risks of surgery, but the ranges of mortality reported in the literature are too broad in most cases to be accurately applied to an individual patient.

We have recently become interested not only in the 30-day mortality after vascular interventions but also in the mortality over the balance of the postoperative year. For carotid endarterectomy and thoracoabdominal aneurysm repair, we have demonstrated continued and significant mortality throughout this time interval.[3,4] Although advancing age clearly predisposed the patients in these studies to higher mortality at both time points, the literature shows that even patients at the extremes of age can undergo surgical procedures safely with proper selection.[5,6] It is important to understand and appreciate, however, the survival of such patients beyond the initial 30-day period may be significantly compromised.

We hypothesized that there would be continued mortality throughout the remainder of the first postoperative year for patients undergoing open repair of AAA in the general population. In addition, we hypothesized that stratifying results by age would demonstrate increasing perioperative and 365-day mortality.

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Competition of interest: none.

Presented at the 33rd Annual Symposium of the Society for Clinical Vascular Surgery, Coral Gables, Florida, March 9-12, 2005.

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0741-5214/$32.00

doi:10.1016/j.jvs.2005.10.071

METHODS

Data source. Discharge data for 1995 to 1999 were obtained from the California Office of Statewide Health Planning and Development (OSHPD). The OSHPD database is compiled annually and includes discharge abstracts from all licensed nonfederal hospitals throughout California. Each discharge record includes the patient's age, gender, race/ethnicity, insurance status, admitting hospital, and source of admission (emergency department vs other;

scheduled vs unscheduled). Discharge diagnoses (up to 24 per hospitalization) and procedures (up to 20 per hospitalization) are also provided. All procedures and diagnoses are categorized by the International Classification of Disease, 9th Clinical Modification (ICD-9) coding scheme. In California, the OSHPD data are linked to the state death certificate file for individual patients, allowing longitudinal follow-up of inpatients after their discharge from the hospital.[7]

Data analysis. All patients undergoing AAA repair (ICD-9 procedure code 38.44 and diagnosis codes 441.4 for intact and 441.3/441.5 for ruptured) in California at nonfederal institutions between 1995 and 1999 were identified. Patients who were not California residents were identified by ZIP code and county of residence and excluded because of the inability to track them after discharge.

The demographic data listed above, as well as Charlson index[8] and annual hospital volume for AAA repair (top 20%, middle 40%, and lowest 40% of total cases performed) were obtained. The Charlson Comorbidity Index, a weighted sum score used to risk-adjust patients, is determined by the presence and severity of 19 conditions, including myocardial infarction, congestive heart failure, diabetes mellitus, and renal disease.

The OSHPD data set provides data on whether the admission is elective (planned >24 hours in advance) or unscheduled. For our cohorts, intact AAA patients were those with a diagnosis of intact AAA and a planned admission, and ruptured AAA patients were those with a diagnosis of ruptured AAA regardless of admission status. Patients with intact aneurysms but unscheduled admission status were excluded (846 patients) owing to the relatively small size of the group and presumed heterogeneity of these cases.

The inpatient file is linked to the state death certificate file, allowing us to determine mortality rates at 30 and 365 days for the patients who underwent AAA repair. Mortality rates were stratified by patient age and intact vs ruptured diagnosis. The mortality rates for AAA patients were also compared with age-matched data from the general population obtained from the National Vital Statistics report of 2002.[9]

It is important to note that for in-hospital and 30-day mortality, these variables are not linked and thus will not have 100% agreement. Patients dying without hospital discharge but >30 days will not be counted as 30-day deaths, and patients dying after discharge but <30 days have elapsed since operation are only counted as deaths within 30 days.

We performed multivariate logistic regression analysis to determine predictors of mortality at three time periods after surgery: 0 to 30 days, 31 to 365 days, and 0 to 365 days, with the independent variables of age, Charlson Comorbidity Index, race, gender, and hospital volume. For the regression model predicting day 31 to 365 mortality, patients who died on days 0 to 30 were excluded. Statistical analyses were performed with SAS version 8.01 (SAS Institute, Cary, NC) and Stata 8.0 (Stata Corp, College Station, Texas). Values of $P < .05$ were considered significant.

Table I. Demographics of all patients (n = 12,406) undergoing abdominal aortic aneurysm repair from 1995 to 1999 by ruptured or intact status

Variable	*Intact (n = 9778)**	*Ruptured (n = 2628)**
Age (years)	72.4 ± 7.2	73.9 ± 8.2
Charlson Comorbidity Index	2.1 ± 1.3	2.4 ± 1.5
Race		
White	91.40	88.60
Black	2.40	3.30
Other	6.20	8.10
Sex		
Male	80.90	80.90
Female	19.10	19.10
Insurance		
Medicare	74.00	71.30
Medicaid	1.50	2.70
Private	23.30	23.60
Other	1.20	2.40
Hospital volume		
High (top 20%)	20.90	12.60
Medium (mid 40%)	44.20	33.50
Low (bottom 40%)	34.90	53.90

*Data are mean ± standard deviation and (%).

RESULTS

A total of 12,406 patients underwent AAA repair in California nonfederal hospitals from 1995 to 1999. The average age was 72.4 (intact) and 73.9 years (ruptured) at the time of procedure; 78.8% of the AAA repairs were performed for intact aneurysms and the balance for ruptured cases. Overall, 90.8% of the patients were white, with no other groups represented by >8.1% of the study population, and 81% were men. Nineteen percent of patients were admitted to high-volume (>32.5 cases/year), 41.6% to medium-volume (16 to 32.5 cases/year), and 39.4% to low-volume hospitals (<16 cases/year). Comparison of the demographic data with respect to intact vs ruptured AAAs are summarized in Table I.

For patients with intact AAAs, mortality was 3.8% in-hospital, 4% at 30 days, and 8.5% at 1 year. Mortality results were also stratified by age in decade as listed in Table II. Percentages shown in the table represent mortality using the total number of patients undergoing operation for each group. For example, the 8.4% mortality for ruptured AAA repair at the 31-day to 365-day time interval represents 220 deaths out of the initial 2,628 patients. This number increases to 15.3% if only patients surviving the initial 30 days are considered (220 deaths out of 1,442 patients). For all patients with intact AAAs >59 years old, the mortality for the balance of the postoperative year was greater than that in the perioperative period. This 31- to 365-day mortality was higher than that for age-matched population data from the National Vital Statistics Report[9] (Fig 1).

For ruptured cases, mortality was 45.7% in-hospital, 45.1% at 30 days, and 53.5% at 1 year. Thirty-day mortality

Table II. Mortality rates stratified by age for abdominal aortic aneurysm repair

Intact	*Overall* n = 9778 (%)	*51-60 yrs* n = 593 (%)	*61-70 yrs* n = 3050	*71-80 yrs* n = 4935	*81-90 yrs* n = 1181	*91-100 yrs* n = 19
In-hospital	3.80	1.50	2.40	4.40	6.10	5.30
30-day	4.00	1.70	2.60	4.40	7.10	10.50
31-365*	4.50	1.20	2.70	5.10	7.60	15.80
365-day	8.50	2.90	5.30	9.50	14.70	26.30
Ruptured	*Overall* n = 2628 (%)	*51-60 yrs* n = 158 (%)	*61-70 yrs* n = 719 (%)	*71-80 yrs* n = 1178 (%)	*81-90 yrs* n = 514 (%)	*91-100 yrs* n = 59 (%)
In-hospital	45.70	29.80	34.90	47.50	58.00	74.60
30-day	45.10	28.50	33.80	46.90	58.20	79.70
31-365 day*	8.40	6.90	5.80	8.60	12	5.10
365-day	53.50	35.40	39.60	55.50	70.20	84.80

*The denominator for this cohort is the total number of patients undergoing operation for each age group.

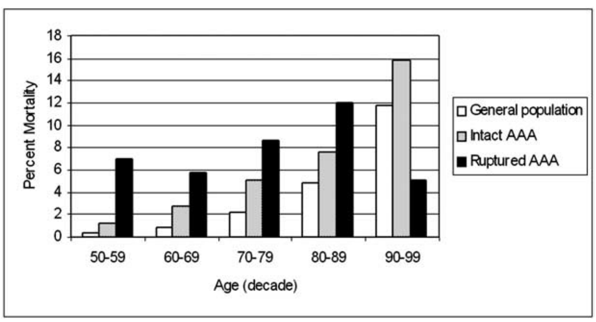

Fig 1. Mortality during postoperative days 31 to 365 for patients undergoing elective and ruptured abdominal aortic aneurysm *(AAA)* repair is shown vs 11 months of age-matched mortality for white men in the United States. The 30-day perioperative mortality is subtracted from the comparison.

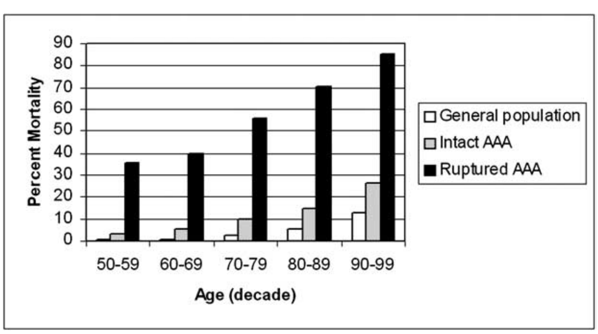

Fig 2. Overall 365-day mortality is displayed for both elective and nonelective abdominal aortic aneurysm *(AAA)* repair, again vs mortality of age-matched population controls for a 1-year period.

was high after AAA repair for the ruptured cases, but mortality between days 31 and 365 was also substantial. One-year mortality was 35.4% for patients 51 to 60 years old and >70% for patients >80 years old (Table II). A comparison of 365-day mortality between AAA patients and age-matched population data from the National Vital Statistics Report is shown in Fig 2.

Multivariate logistic analysis was performed for predictors of 30-day, day 31 to 365, and 1-year mortality. For all patients, advancing age and Charlson Comorbidity Index were independent risk factors for mortality at all time points, while controlling for the other independent variables included in the regression model. Female gender was associated with increased odds of mortality for all but patients with intact AAA repairs at the 31- to 365-day interval. Black race was associated with increased odds of late mortality for intact AAA operations (31 to 365 days and 1 year), and for patients with a ruptured AAA, the association was decreased odds of mortality at 0 to 30 days and 1 year. Volume analysis demonstrated a mortality association with low-volume hospitals for patients with both intact and ruptured AAA at the 30-day and 1-year time periods. These data, as well as associations of mortality with insurance status, are summarized in Tables III, IV, and V.

DISCUSSION

In this study, we report the 365-day mortality for open AAA repair in a large group of patients (12,406) from the general population. As we hypothesized, there is continued mortality for these patients beyond the initial 30-day period above what would be anticipated in the general population. In addition, mortality at all time points increases with patient age. The linkage of OSHPD to the state death files allows these observations to be made and adds a new dimension to studies that used large administrative databases. Because AAA repair is performed to prolong life, 1-year mortality should be an important consideration when contemplating this operation.

Our results for elective AAA repair demonstrate mortality rates of 3.8% for the in-hospital interval and 4.5% at 30 days. Mortality in single-institution reviews tends to be lower, from 0% to 1.2%.[10,11] This contrasts with 8.4% inpatient mortality using the National Hospital Discharge data[12] and 4.2% using the Nationwide Inpatient Sample (NIS).[13] These differences may represent volume-outcome discrepancies, as a report has shown twice the mortality for surgeons who perform fewer than four AAA repairs a year vs

Table III. Multivariate logistic regression model predicting 30-day mortality

	Intact (n = 9778)		Ruptured (n=2628)	
30-day mortality	*OR*	*95% CI*	*OR*	*95% CI*
Age (years)	1.06*	(1.04, 1.08)	1.06*	(1.05, 1.07)
Female	1.56*	(1.23, 1.97)	1.33*	(1.08, 1.63)
Charlson Comorbidity Index	1.41*	(1.33, 1.49)	1.07*	(1.01, 1.13)
Race				
White	1	—	1	—
Black	1.22	(0.64, 2.34)	0.50*	(0.31, 0.80)
Other race	1.01	(0.66, 1.55)	0.88	(0.66, 1.19)
Insurance				
Medicare	1	—	1	—
Medicaid	1.64	(0.74, 3.61)	1.83*	(1.09, 3.07)
Private	1.08	(0.81, 1.44)	1.30*	(1.07, 1.59)
Other	2.91*	(1.37, 6.16)	1.74*	(1.02, 2.98)
Annual hospital volume				
High	1	—	1	—
Middle	1.42*	(1.05, 1.92)	1.07	(0.82, 1.39)
Low	1.71*	(1.26, 2.32)	1.54*	(1.20, 1.98)

OR, odds ratio; *CI,* confidence interval.
*$P < .05$.

Table IV. Multivariate logistic regression model predicting 31- to 365-day mortality*

	Intact (n = 9338)		Ruptured (n = 1442)	
31- to 365-day mortality	*OR*	*95% CI*	*OR*	*95% CI*
Age (years)	1.07†	(1.05, 1.09)	1.07†	(1.05, 1.09)
Female	1.04	(0.81, 1.33)	1.49†	(1.02, 2.17)
Charlson Comorbidity Index	1.42†	(1.35, 1.50)	1.52†	(1.37, 1.68)
Race				
White	1	—	1	—
Black	1.91†	(1.11, 3.30)	0.62	(0.27, 1.47)
Other Race	1.09	(0.73, 1.64)	1.19	(0.71, 1.99)
Insurance				
Medicare	1	—	1	—
Medicaid	1.5	(0.68, 3.30)	1.08	(0.35, 3.31)
Private	0.89	(0.67, 1.18)	1.36	(0.94, 1.99)
Other	1	(0.31, 3.20)	2.18	(0.78, 6.09)
Annual hospital volume				
High	1	—	1	—
Middle	0.92	(0.71, 1.20)	1.2	(0.73, 1.97)
Low	1.08	(0.83, 1.40)	1.25	(0.78, 2.00)

OR, Odds ratio; *CI,* confidence interval.
*Please note, the samples sizes do not include patients with mortality during the first 30 days.
†$P < .05$.

those who perform >10.[14] In addition, a meta-analysis of 64 AAA studies demonstrates an overall mortality of 5.5% at 30 days.[15]

Few studies address 365-day mortality, with rates of 6% to 10.8% for intact AAA repair and 45.9% to 53% for ruptured AAA.[8,16,17] Our overall 1-year mortality data for intact (8.5%) and ruptured (53.5%) AAAs are close to these figures; however, it is revealing to note the large range in these numbers when stratified by age. A number of 10% is clearly unrealistic for both the 55-year-old patient (365-day mortality of 2.9%) and the 85-year-old (365-day mortality of 14.7%).

Several studies have reported volume-based outcomes after AAA, with more favorable results at higher-volume centers.[18,19] Our data are in agreement with these findings, since low-volume hospitals demonstrate increased odds of both 30-day and 365-day mortality for intact and ruptured AAA. In addition, increasing age and Charlson score are, as expected, predictors of increased mortality at all time points and for both intact and ruptured cases.

This current review has several limitations. One problem in evaluating the mortality for AAA repair via administrative databases is the lack of data regarding aneurysm size. In addition, there is also the issue of selecting out for less

Table V. Multivariate logistic regression model predicting 365-day mortality

	Intact (n = 9778)		Ruptured (n = 2628)	
365-day mortality	*OR*	*95% CI*	*OR*	*95% CI*
Age (years)	1.07*	(1.06, 1.08)	1.07*	(1.06, 1.08)
Female	1.28*	(1.07, 1.53)	1.42*	(1.15, 1.75)
Charlson Comorbidity Index	1.48*	(1.41, 1.55)	1.20*	(1.14, 1.28)
Race				
White	1	—	1	—
Black	1.60*	(1.04, 2.47)	0.49*	(0.31, 0.79)
Other Race	1.05	(0.78, 1.43)	0.97	(0.72, 1.30)
Insurance				
Medicare	1	—	1	—
Medicaid	1.58	(0.88, 2.81)	1.81*	(1.06, 3.09)
Private	0.98	(0.79, 1.20)	1.39*	(1.13, 1.70)
Other	1.92	(1.00, 3.68)	2.00*	(1.16, 3.42)
Annual hospital volume				
High	1	—	1	—
Middle	1.1	(0.90, 1.35)	1.12	(0.86, 1.45)
Low	1.31*	(1.06, 1.61)	1.56*	(1.21, 2.00)

OR, Odds ratio; *CI,* confidence interval.
*$P < .05$

technically demanding cases by limiting coding to the simplest operations.[10] This issue was addressed in studies that showed AAA data remained unchanged when codes were used for more complex disease.[20,21]

Mention should also be made regarding the absence of endovascular aneurysm repair (EVAR) data in this report. Given the study years, it is unlikely that our population contained a significant number of EVAR cases. Advantages have now been shown in terms of quality-of-life parameters, recovery time, and length of hospitalization for EVAR.[22-24]Decreased perioperative mortality vs open repair has been reported, but this is not a consistent finding.[14,25,,26] It is interesting to note that the 1-year mortality in the Guidant trial was 6%.[27] This is the same number found in The Cleveland Clinic's study of open cases at 365 days.[8] More recent data show no long-time survival benefit for endovascular vs open repair.[28,29] All of these reports represent the experiences of specialized centers, and this underscores the importance of establishing the age-stratified mortality for EVAR in the general population.

Finally, our data are predominantly drawn from a white male population. Although these data are consistent with prior administrative database analyses of patients undergoing AAA repair and other vascular procedures, the findings may have limited application to other patients.[30,31] Our regression analysis does allow for an examination of gender and race, but where no association with mortality was identified, the small numbers of women and minorities in the current cohort may play a role. Further study with minority and female patients is warranted.

CONCLUSIONS

Our study demonstrates the continued mortality after open repair of both intact and ruptured AAAs. Age stratification gives a more accurate view of mortality at both the 30 and 365-day time points for a particular patient, information that is potentially very helpful in clinical decision-making. A more meaningful patient provider discussion is likely when these focused data are used, so that an 85-year-old and his or her physician can consider 15% mortality rather than the 3% mortality more appropriate for a patient in their 50s. It should also be remembered that we are only presenting data on mortality, and there can also be serious morbidity associated with AAA repair.

This study raises the question of what is causing the mortality, particularly since it is significantly higher than that of the background general population. It may represent delayed or lingering complications, the role of aneurysmal disease as a marker of early mortality, or even the role of the postsurgical inflammatory response in decreased life expectancy.[32] This may offer an opportunity for risk reduction in the postsurgical patient and is an area deserving of increased investigation.

AUTHOR CONTRIBUTIONS

Conception and design: D.A.R., S.Z., A.M., Y.K.
Analysis and interpretation: D.A.R., M.L.M., F.L., Y.K.
Data collection: D.S.Z., M.A.M., C.Y.K.
Writing the article: D.A.R.
Critical revision of the article: D.A.R., S.Z., M.L.M., A.M., P.F.L, Y.K.
Final approval of the article: D.A.R., S.Z., M.L.M., A.M., F.L., Y.K.
Statistical analysis: D.S.Z., L.M., A.M., Y.K.
Obtained Funding: C.Y.K.
Overall responsibility: D.A.R.

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Submitted Mar 18, 2005; accepted Oct 24, 2005.