Predictors of repair and effect of gender on treatment of ruptured abdominal aortic aneurysm

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Objective: **The purpose of this study was to determine factors associated with increased likelihood of patients undergoing surgery to repair ruptured abdominal aortic aneurysms (AAAs). Specifically, we investigated whether men were more likely than women to be selected for surgery after rupture of AAAs.**

Methods: **All patients with a ruptured AAA who came to a hospital in Ontario between April 1, 1992, and March 31, 2001, were included in this population-based retrospective study. Administrative data were used to identify patients, patient demographic data, and hospital variables.**

Results: **Crude 30-day mortality for the 3570 patients who came to a hospital with a ruptured AAA was 53.4%. Of the 2602 patients (72.9%) who underwent surgical repair, crude 30-day mortality was 41.0%. Older patients (odds ratio [OR], 0.649 per 5 years of age; $P < .0001$), with a higher Charlson Comorbidity Index (OR, 0.848; $P < .0001$), were less likely to undergo AAA repair. Patients treated at high-volume centers (OR, 2.674 per 10 cases; $P < .0001$) and men (OR, 2.214; $P < .0001$) were more likely to undergo AAA repair.**

Conclusion: **Men are more likely to undergo repair of a ruptured AAA than women are, for reasons that are unclear. Given the large magnitude of the effect, further studies are clearly indicated. (J Vasc Surg 2004;39:784-7.)**

There is disagreement in the literature about the effect of gender on survival after repair of ruptured abdominal aortic aneurysm (AAA). Some studies indicate that survival is superior in men,[1,2] and others that gender has no effect on survival.[3,4] There has also been some suggestion that women with ruptured AAAs are less likely than men to receive surgery.[2-4]

Data from Scandinavia demonstrate that many patients with a ruptured AAA die before reaching the operating room.[5] This study showed that 42% of all patients die outside of hospital, and almost 50% of those who do reach a hospital die without surgery.[5] Because it is extremely difficult to aid patients outside of the hospital, ensuring that patients who survive to the hospital receive optimal treatment is important to reduce deaths from ruptured AAAs.

The purpose of this study was twofold. First, we determined those factors that affected the likelihood that patients with a ruptured AAA would undergo repair. Specifically, we investigated whether gender had an effect on whether patients underwent repair. Second, we sought to investigate the survival of patients who reached the hospital with a ruptured AAA but did not undergo surgery.

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METHODS

Data sources. Data were obtained from three sources: the Canadian Institute for Health Information (CIHI) database, the Ontario Health Insurance Plan (OHIP) database, and census data. These data sources were linked with a confidential unique identifier.

All patients who reached an Ontario hospital with a ruptured AAA between April 1, 1992, and March 31, 2001, were considered. The CIHI database records information regarding all hospital admissions in Ontario through the use of International Classification of Diseases, revision 9, diagnostic and procedure codes. Patients without repair were defined as those who had a most responsible diagnosis of ruptured AAA (441.3) but no procedure code for repair in either the CIHI database (procedure code 38.44) or the OHIP database. The OHIP database, which captures 95% of all physician billings in Ontario, was used to identify patients who underwent repair of a ruptured AAA through the use of unique codes (R802, R816, or R817, and E627). Patients who were operated on by surgeons who are paid by salary do not appear in OHIP, and were excluded. Ethics approval was obtained from the local institutional review board.

Patient factors. Information regarding patient age and gender was obtained from census data. Comorbidity was quantified by the Charlson Comorbidity Index,[6] which was calculated on the basis of preoperative comorbid conditions recorded in the CIHI hospital discharge abstract database.[7] Information about individual patient income was not available. With postal codes and census data, socio-

Table I. Patient characteristics

Parameter	*All patients*	*Patients with repair*	*Patients without repair*	P*
30-day mortality (%)	53.4	41.1	89.9	<.0001
Age (y)	73.8 ± 9.7	72.0 ± 8.9	79.2 ± 9.9	<.0001
Charlson Comorbidity Score	0.69 ± 1.10	0.66 ± 1.05	0.81 ± 1.25	.02
Male gender (%)	75.7	81.1	59.7	<.0001
Distance from hospital (km)	25.0 ± 79.7	27.2 ± 58.4	18.8 ± 122.2	.05
Population of city hospital located in	265,000 ± 217,000	282,000 ± 213,000	216,000 ± 224,000	<.0001
Annual hospital volume of RAAA repairs	9.0 ± 7.1	10.0 ± 7.3	5.9 ± 5.5	<.0001

Data represent means ± SD.
RAAA, Ruptured abdominal aortic aneurysm.
*Patients with repair vs patients without repair.

economic status was determined by using the average income of a neighborhood, which was then applied to all patients from that neighborhood. The population was then divided into roughly equal quintiles for analysis. The distance between a patient's home and the treating hospital represents a straight line distance, and was calculated with the longitude and latitude for each location.

Hospital factors. The hospital at which patients received treatment is contained in the CIHI database. Teaching hospitals were defined as those that had a regular complement of residents. We used census data to determine the population of the city the hospital was located in. Annual hospital volumes were calculated by enumerating the number of operations performed at a hospital in a given calendar year. The year the operation took place was determined by the date of admission.

Statistical analysis. All analyses were performed with the SAS statistical package (version 8.2; SAS Institute, Cary, NC), with an alpha level of .05 to determine statistical significance. Two-tailed *t* tests were used to compare continuous variables, and χ^2 analysis was used for categorical data. Kaplan-Meier survival estimates were used to track the outcome in patients who did and did not undergo AAA repair.

To determine predictors of patients undergoing repair of a ruptured AAA, diagnostics for colinearity were undertaken. A correlation table of all variables was constructed, and the variation inflation factors were examined. Annual hospital volume of elective operations and those performed to repair ruptured AAAs was highly correlated ($r = 0.816$), and annual volume of elective operations had a higher variation inflation factor compared with annual volume of operations to treat ruptured AAAs. For this reason, and because it was more strongly correlated with survival on univariate analysis, only hospital volume of ruptured AAAs was included in multivariate modeling.

A logistic regression backward selection procedure was used to determine variables associated with patients undergoing repair of a ruptured AAA. The model was then rerun with only the significant variables, which reclaimed some observations that were previously excluded because of missing values for nonsignificant variables.

Table II. Significant predictors of undergoing repair for patients with RAAA in ER, from logistic regression backwards selection model

Parameter	*OR**	*95% CI*	P
Age (per 5 years)	0.65	0.615-0.684	<.0001
Charlson Comorbidity Score, for increase of 1	0.85	0.789-0.912	<.0001
Male gender	2.21	1.837-2.668	<.0001
Hospital volume of ruptured AAAs (per 10 cases)	2.67	2.263-3.160	<.0001

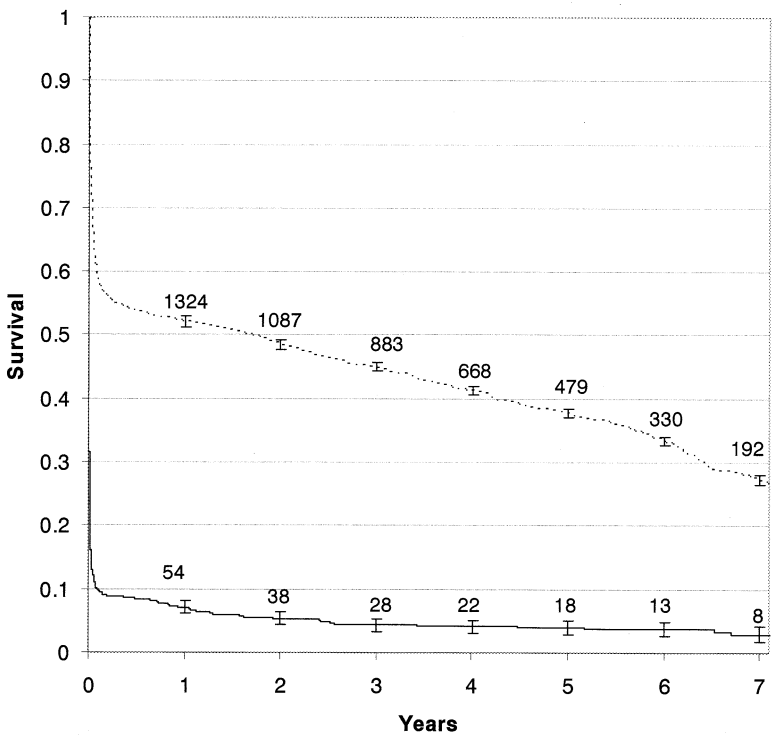
RAAA, Ruptured abdominal aortic aneurysm; *ER,* emergency room; *OR,* odds ratio; *CI,* confidence interval.
*OR <1 decreased likelihood of receiving repair; OR >1, increased likelihood of receiving repair.

RESULTS

We identified 3570 patients with ruptured AAAs, 968 (27.1%) of whom did not undergo AAA repair. Crude 30-day mortality for all patients was 53.4%, 41.0% for those who did undergo repair, and 90.0% for those who did not undergo repair. Some differences between those who underwent repair and those who did not are shown in Table I. Compared with patients who did undergo repair, patients who did not undergo repair were older ($P < .0001$), had a higher Charlson Comorbidity Index ($P = .0017$), were more often women ($P < .0001$), and received treatment at lower volume hospitals ($P < .0001$) and hospitals in smaller cities ($P < .0001$).

Significant independent predictors for undergoing AAA repair are summarized in Table II. Older, sicker patients were less likely to undergo repair, and men were much more likely to undergo repair compared with women, as were patients admitted to high-volume hospitals.

Gender had a striking effect on the way in which patients were treated. Eighty percent of men underwent repair, compared with 58% of women (Table III). Although women were significantly older then men ($P < .0001$), they were no sicker as measured with the Charlson Comorbidity Index ($P = .72$). Men tended to receive treatment in higher volume hospitals ($P < .0001$) and in larger cities ($P = .04$). The effect of gender on the likeli-



Kaplan-Meier survival curves for patients with repair *(dashed line)* and no repair *(solid line)* after rupture of AAA. Standard error and number of patients remaining are provided for each year.

Table III. Characteristics of patients by gender

Parameter	*Men*	*Women*	P
Age (y)	72.8 ± 9.3	77.0 ± 10.1	<.0001
Charlson Comorbidity Score	0.70 ± 1.12	0.69 ± 1.05	.72
Distance from hospital (km)	26.1 ± 87.6	21.7 ± 47.4	.07
Population of city hospital located in	269,000 ± 218,000	251,000 ± 216,000	.04
Annual hospital volume of RAAA repairs	9.3 ± 7.2	8.2 ± 6.7	<.0001
Received repair (%)	80.0	58.0	<.0001

Data represent mean ± SD.

hood of repair was much greater in patients older than the median age of 74 years, and older women were much less likely to receive AAA repair (47.9%) compared with older men (71.0%), younger men (88.2%), or younger women (77.7%). The interaction between age and gender was not significant at multivariate modeling.

The 5-year survival for patients undergoing AAA repair was 37.9% (Fig) .

DISCUSSION

That 25% of patients with a ruptured AAA who reached a hospital did not undergo surgery might be surprising. However, without more detailed clinical data we cannot comment on the appropriateness of this finding.[7-13] Many patients who did not undergo surgery may have been in extremis, may have previously indicated a wish to not be resuscitated, or had other compelling reasons not to undergo surgery.

Patients who did undergo repair tended to receive treatment in high-volume centers. This may reflect a survival advantage in that patients who were transferred to a high-volume center were likely stable enough to survive transfer. Men, particularly older men, were more likely to undergo a repair than were women, but the reason for this is not clear. Although there were differences between men and women related to some characteristics, most noticeably age, the gender effect persisted at multivariate analysis, similar to other reports.[2-4] There may also have been differences between men and women in unmeasured characteristics, such as accuracy of diagnosis, type of aneurysm, duration of symptoms outside of hospital, and detailed differences in preoperative risk, such as left ventricular

function. Further study of the reasons for this gender effect is clearly indicated.

As expected, most deaths in both groups occurred soon after AAA rupture. The 30-day survival for patients with repair was 41.0%, similar to other contemporary series.[11,14-17] For patients who did not undergo repair, our 30-day survival rate was 10.1%, similar to previous work.[18] Among patients who did not undergo repair, survival was 7.1% at 1 year. Most likely these patients had symptomatic rather than true ruptured AAAs.

The limitations of our study deserve mention. We retrospectively used administrative data; detailed clinical information such as aneurysm type and blood pressure at admission was not available. Although it is likely that the billing data for surgical repair of an AAA is accurate, some patients who died in the emergency department of ruptured AAA may not have been captured. However, this should not affect the influence of gender on the likelihood of repair, and it is reassuring that the survival rates in our study are similar to others published in the literature.

In summary, older and sicker patients are less likely to undergo repair of a ruptured AAA. Those who receive treatment at high-volume centers, and in particular, men, are much more likely to undergo AAA repair. The reasons why men are more likely than women to undergo repair of a ruptured AAA is unclear, and warrants further study.

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