Gender differences in abdominal aortic aneurysm prevalence, treatment, and outcome

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Purpose: **The purpose of this study was to investigate gender differences in the management of and outcome of surgery for abdominal aortic aneurysms (AAA).**
Methods: **Hospital discharge data from all acute care hospitals in Michigan, as compiled in the Michigan Inpatient Data Base, were retrospectively analyzed to assess sex differences in regard to AAA prevalence, treatment, and surgical outcome from 1980 to 1990. This population database included 11,512 women and 29,846 men 50 years of age and older with diagnoses of intact or ruptured AAA.**
Results: **Hospitalizations for intact or ruptured AAA were approximately five times more common among men compared with women. After controlling for age and year of surgery, men were 1.8 times as likely as women to have an intact AAA treated surgically and 1.4 times as likely to have a ruptured AAA treated surgically (95% confidence intervals, 1.7 to 1.9 and 1.2 to 1.7, respectively). Women who had operations for intact AAA had a 1.4 times greater risk of dying compared with men, and women who had operations for ruptured AAA had a 1.45 times greater risk of dying, after controlling for other predictors of death (95% confidence intervals, 1.14 to 1.73 and 1.10 to 1.90, respectively).**
Conclusions: **In a population-based statewide experience, women who had intact or ruptured AAA were less likely than men to undergo aortic reconstruction and, when they did, were less likely than men to survive to discharge. (J Vasc Surg 1997;25:561-8.)**

Few studies of peripheral vascular surgery have included enough women to determine whether gender differences exist in diagnosis, management, and treatment outcome.[1,2] The issue of gender differences is important because of the increasingly high volume of peripheral vascular surgery being performed in the United States.[3] Of particular concern is the possibility that gender differences might contribute to the relatively high mortality rate associated with repair of abdominal aortic aneurysms (AAA).[4,5]

A recent report on trends in the treatment of AAA in Michigan suggested that women have a higher perioperative mortality rate for aortic aneurysm repair.[5] The present report is a detailed analysis of gender differences in the prevalence, treatment, and outcome of surgery for intact and ruptured AAA. The study was designed to test the hypothesis that there were specific differences in prevalence, treatment, and outcome among men and women with AAA.

METHODS

Study population and variables

The Michigan Inpatient Data Base (Michigan Health Data Corporation, Lansing, Mich.) provided information on all 47,739 admissions of patients to Michigan acute care hospitals from 1980 through 1990 that included (1) intact or ruptured AAA as the principal diagnosis or any of six secondary diagnoses (codes 441.4 and 441.3, respectively, International Classification of Diseases, 9th Revision, Clinical Modification, ICD-9-CM[6]), or (2) resection of the aorta with replacement (code 38.44) as the principal procedure or any of six secondary procedures. The sample included 41,358 admissions after exclusion of

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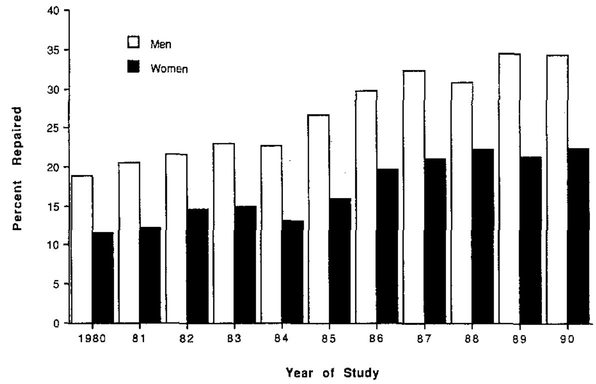

Fig. 1. Age-adjusted proportions of women and men hospitalized with principal or secondary diagnosis of intact AAA who underwent surgical repair in Michigan, 1980 to 1990. Sample included 10,830 admissions for women and 27,127 admissions for men ($p = 0.0001$ for comparison between women and men, after adjustment for age and year of surgery, by logistic regression).

thoracic aneurysms and exclusion of other or unspecified sites, as well as aneurysms associated with Marfan's syndrome, trauma, and congenital defects.

Calculation of the proportions of men and women who underwent surgery for treatment of intact AAA was based on primary and secondary diagnoses of AAA with either of two treatment codes, 38.44 or 38.34 (resection of the aorta with anastomosis). Calculation of surgical mortality rates was based only on AAA admissions that were principal diagnoses and had treatment code 38.44 as the principal procedure, to provide consistency in the type of repair performed over the 11 years of the study period. A sensitivity analysis assessed the effect of including secondary diagnoses and additional procedure codes (38.34, 38.64 [excision of aorta not otherwise specified], 39.25 [aorta-iliac-femoral bypass], 39.52 [other repair of aneurysm], and, for ruptured AAA, 54.11, 54.12, 54.19, and 54.21 [to include laparotomy]). Information available on each admission included age, gender, race, length of hospital stay, discharge status, primary diagnosis and procedure, as many as six secondary diagnoses and procedures, and the hospital's annual surgical volume for the treatment of intact or ruptured AAA. Variables that were assessed in this study were those known to be associated with overall surgical mortality risk.[5]

Statistical analysis

Time trends in rates of AAA diagnosis and surgery were assessed with χ^2 tests for trend,[7] and t tests and linear regression were used to compare age differences between men and women. Gender differences in the probability of treatment and survival to discharge were initially examined with relative risks and 95% confidence intervals (CI) after stratification to evaluate potential confounders. Logistic regression assessed the effect of gender after controlling for all known confounders.[8] Because preliminary analysis showed that age was associated with surgical death in a curvilinear fashion, age squared was also tested in the models. Age was assessed as the true value minus the mean age of all patients to reduce the strong correlation between age and its squared value.[9]

RESULTS

Gender differences in prevalence and age

Men were hospitalized with principal diagnoses of intact AAA at an age-adjusted mean annual rate of 108.1 per 100,000 population age 50 and older, and women at an average rate of 22.5 per 100,000. These rates and their ratio (4.8:1) showed no significant trends over time. For ruptured AAA, the male:female admissions ratio averaged 5:1 (22.6 per 100,000 for men, 4.5 per 100,000 for women) and showed only minor year-to-year fluctuations. Of the 10,830 female admissions with any mention of intact AAA, 30.7% were principal diagnoses, compared with 47.2% for male admissions.

Women were significantly older than men at admission and operation for AAA ($p < 0.001$ for all comparisons). Women's average ages at admission for intact and ruptured AAA were 73.0 ± 7.8 years (mean ± standard deviation) and 77.4 ± 9.3 years, respectively. The average ages at admission for intact and ruptured AAA in men were 69.4 ± 8.0 years and 71.9 ± 8.8 years, respectively. Women's average ages at surgery for intact and ruptured AAA were 72.1 ± 7.8 years and 76.0 ± 9.3 years, compared with 69.1 ± 7.6 years and 71.0 ± 8.2 years for men.

Treatment of intact and ruptured AAA

The probability that a patient would undergo surgery for AAA increased significantly over the period studied for both sexes ($p = 0.0001$) but was consistently lower for women, even after adjustment for women's older ages at admission and at surgery (Figs. 1 and 2). Although bivariate and multivariate analyses identified other variables that were significantly associated with the probability of AAA repair (number of comorbidities, the hospital's volume of AAA surgery, cardiac ischemia, hypertension, and renal failure), inclusion of these variables in a logistic

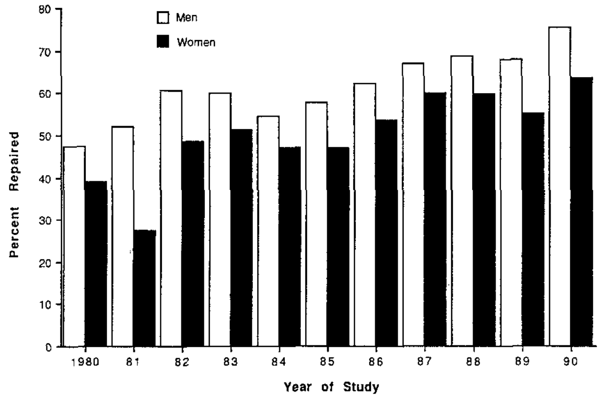

Fig. 2. Age-adjusted proportions of women and men hospitalized with ruptured AAA who underwent surgical repair in Michigan, 1980 to 1990. Sample included 682 women and 2719 men (p = 0.0002 for comparison between women and men, after adjustment for age and year of surgery, by logistic regression).

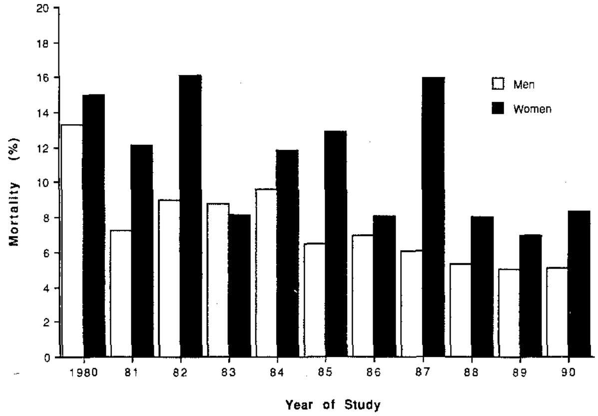

Fig. 3. Comparison of perioperative mortality data for men and women with principal diagnosis of intact AAA who underwent surgical repair in Michigan, 1980 to 1990. Sample included 6716 men and 1469 women (p = 0.002 for comparison of female and male mortality data, by logistic regression).

regression equation did not change the odds ratio for the effect of gender.

From 1980 to 1990, 14.9% of women who were admitted with a principal or secondary diagnosis of intact AAA were treated surgically, compared with 27.3% of men (p = 0.0001) who were treated with operation. Women's age-adjusted probability of surgery increased from 11.6% in 1980 to 22.4% in 1990. The proportion of men undergoing aneurysm repair increased from 19% in 1980 to 34.3% in 1990 (Fig. 1). Overall, men were 1.8 times as likely as women to undergo aortic reconstruction for an intact AAA (95% CI, 1.7 to 1.9) after adjustment for age and year of operation.

Ruptured AAA were treated surgically in 61.3% of men compared with 49.1% of women ($p < 0.001$). For women, the age-adjusted probability of surgery for ruptured AAA increased from 39.0% in 1980 to 63.2% in 1990; for men, the probability rose from 47.4% in 1980 to 75.4% in 1990 (Fig. 2). Overall, men were 1.4 times as likely as women to undergo surgery for ruptured AAA (95% CI, 1.2 to 1.7). This difference was greater from 1980 to 1984 (odds ratio, 1.7; 95% CI, 1.3 to 2.2) than from 1985 to 1990 (odds ratio, 1.3; 95% CI, 0.97 to 1.6).

Perioperative mortality data

The inpatient mortality rate for 8185 men and women who underwent aortic reconstruction for intact AAA decreased significantly from 1980 to 1990 but was consistently higher among women (Fig. 3). The increased risk was evident across most variables studied (Table I). A logistic regression equation that controlled for all apparent confounders yielded an odds ratio of 1.4 for the comparison of female with male perioperative mortality rates (Table I). This suggests that women had as much as a 40% greater risk of dying after operation for intact AAA. An analysis that included all secondary diagnoses of AAA and five surgical procedure codes, representing 10,770 admissions, produced a similar odds ratio of 1.49 (95% CI, 1.26 to 1.77). Separate logistic regression equations for men and women revealed few differences in risk factors for perioperative death (Table II).

The analysis of 1829 ruptured AAAs that were treated with operation also revealed different trends for men and women (Fig. 4). Perioperative mortality rates were static over time for men (46.9% in 1980, 48.4% in 1990; p = 0.9), but increased for women (47.4% in 1980, 60.5% in 1990; p = 0.08). Women with ruptured AAA had significantly greater perioperative mortality rates across many potential confounders (Table III). The risk was greater for younger women patients and in the more recent 1985 to 1990 time period. Controlling for all potential confounders produced an odds ratio of 1.45, suggesting that women had as much as a 45% greater risk of dying than men after repair of a ruptured AAA. A sensitivity analysis that included six additional procedure codes representing 2145 admissions for ruptured AAA produced a similar odds ratio of 1.47 (95% CI, 1.14 to 1.90).

Separate logistic regression equations for men and women (Table IV) documented additional gen-

Table I. Effect of gender on perioperative mortality rate for intact AAA

Variable	*No. of patients*		*Mortality rate*		*Mortality Ratio** *(95% CI)*	*p*
	Men	*Women*	*Men*	*Women*		
Age						
50–69 years	3481	534	4.11	5.06	1.23 (0.82-1.83)	0.31
70 years or older	3235	935	9.77	13.96	1.40 (1.16-1.70)	0.001
Comorbidities						
0-3	3854	790	4.33	7.09	1.64 (1.22-2.19)	0.001
4 or more	2862	679	10.20	14.58	1.43 (1.16-1.77)	0.001
Year of surgery						
1980-84	2036	447	9.38	12.30	1.31 (0.99-1.74)	0.06
1985-90	4680	1022	5.73	9.78	1.71 (1.37-2.13)	<0.001
Ischemic heart disease						
Yes	2037	394	7.41	10.91	1.47 (1.07-2.03)	0.02
No	4679	1075	6.58	10.42	1.58 (1.29-1.95)	<0.001
Renal failure						
Yes	251	75	37.05	49.33	1.33 (1.01-1.76)	0.06
No	6465	1394	5.66	8.46	1.49 (1.23-1.82)	<0.001
Hypertension						
Yes	1971	538	3.86	7.25	1.88 (1.29-2.73)	0.001
No	4745	931	8.07	12.46	1.54 (1.27-1.88)	<0.001
Dysrhythmia						
Yes	926	156	13.17	16.03	1.22 (0.82-1.80)	0.34
No	5790	1313	5.82	9.90	1.70 (1.40-2.06)	<0.001
Hospital AAA surgical volume						
1 to 20/year	3220	747	8.20	11.65	1.42 (1.13-1.79)	0.003
21 or more/year	3496	722	5.58	9.42	1.67 (1.30-2.20)	<0.001
All variables	6716	1469	6.8	10.6	1.40 (1.14-1.73)†	0.002

Adjusted for individual risk factors by stratification and for all confounders by multivariate analysis.
*For individual variables, the statistic shown is a risk ratio that compares female to male mortality data at the specified level of the variable.
†Odds ratio controlled by logistic regression for age, number of comorbidities, year of surgery, hospital surgical volume, and presence of ischemic heart disease, renal failure, hypertension, and dysrhythmias.

Table II. Results of logistic regression analysis of predictors of perioperative death for repair of intact AAA in 1469 women and 6716 men, 1980 to 1990

Variable	*Regression Coefficient*		*Odds Ratio*		*95% CI*		*p*	
	Men	*Women*	*Men*	*Women*	*Men*	*Women*	*Men*	*Women*
Renal failure	1.94	2.10	6.96	8.17	5.15-9.44	4.80-13.84	<0.001	<0.001
Year of surgery	−0.12	−0.10	3.32†	2.72†	2.36-4.76	1.48-5.00	<0.001	0.002
Comorbidities	0.75	0.86	2.10	2.36	1.69-2.65	1.60-3.46	<0.001	<0.001
Hypertension	−0.75	−0.63	0.47	0.53	0.36-0.62	0.35-0.80	<0.001	0.003
Age	0.05‡	0.08	2.00§	2.23*	1.60-2.49	1.76-2.89	<0.001	<0.001
Dysrhythmia	0.67	0.17	1.95	1.19	1.54-2.51	0.70-1.99	<0.001	0.53
Hospital AAA surgical volume	0.24	0.21	1.27	1.23	1.04-1.57	0.85-1.78	0.02	0.27

Variables used in the final logistic regression models were coded as follows: renal failure, dysrhythmia, and hypertension: 0 = no, 1 = yes; year of surgery: 1 (1980) to 11 (1990); comorbidities: 0 = 3 or fewer, 1 = 4 or more; hospital volume: 0 = 21 or more per year, 1 = 20 or fewer per year.
*Comparing age 82 with age 72.
†Comparing 1980 with 1990.
‡Coefficient for age squared = 0.00207 for men (age squared was not significant in the model for women). Model sets mean age to zero and measures risk by number of years above or below the mean.
§Comparing age 79 with age 69.

der differences in risk factors for surgical death associated with ruptured AAA. Year of surgery, cerebrovascular disease, and ischemic heart disease predicted death in women but not in men. The apparent survival advantage for patients with more comorbidities probably is an artifact of coding, reflecting the longer mean stay of patients who survived (20 days, compared with 8.3 days for patients who died); this gave hospital personnel more time to find and document comorbidities.

DISCUSSION

The present study, which is a continuation of the largest report on AAA treatment and outcome,[5] documented gender differences in the surgical management and short-term outcome of surgery for repair of intact and ruptured AAA. Women with intact AAA were about half as likely as men to undergo surgery, and this gender gap varied little during the study period. Women who did undergo operations for intact AAA had an estimated 40% increased risk of dying during or shortly after surgery. Among women with ruptured AAA, the probability of surviving the operation was significantly less than for men and actually worsened in recent years.

Data from other studies support the existence of unexplained gender differences in treatment for AAA. In a recent review, Ernst noted that AAA was responsible for 14,982 deaths annually in the United States, 34% of them in women.[4] This 2:1 male to female mortality ratio is in contrast to incidence and prevalence ratios of approximately 5:1 reported in our study and in reviews of the epidemiologic variables of AAA.[10,11] Because most AAA deaths are the result of rupture, a mortality ratio that is smaller than the incidence ratio implies that women's AAAs are less likely to be repaired and therefore more likely to progress to rupture. In this regard, the Canadian Aneurysm Study Group investigators reported that women represented only 18% of cases in their collected series of surgical repair of AAA.[2] They noted that this proportion was less than that observed in autopsy studies, ultrasound screening studies, hospital discharge data, and national mortality data, and they speculated that this difference may reflect biases in the diagnosis and treatment of AAA in women.

The magnitude of the treatment difference observed in this study of AAA is similar to that reported for treatment of coronary artery disease. Investigators have speculated that the apparent tendency to be less aggressive in the treatment of women with coronary artery disease may be a result of patients' preferences, the perception that the disease has a more benign course in women, or the belief that the intervention is more hazardous in women.[12,13] Others have suggested that cardiovascular disease is perceived as a disease of men because most studies of diagnosis, prevention, and treatment have involved male patients.[14] Such factors also may affect the treatment of AAA.

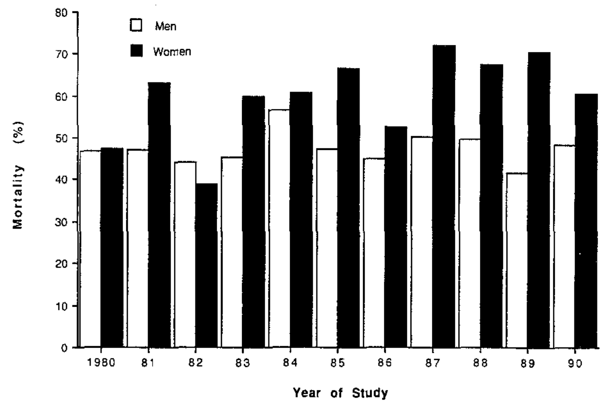

Fig. 4. Comparison of perioperative mortality data for men and women with ruptured AAA who underwent surgical repair in Michigan, 1980 to 1990. Samples included 307 women and 1522 men ($p = 0.008$ for comparison of female and male mortality data, by logistic regression).

Another explanation is the higher prevalence of being overweight among women,[15] which might affect the decision to operate. However, although surgeons may defer elective operation in the very obese, obesity as a comorbidity in the present study occurred in near equal proportions of men and women (1.3% of men, 1.4% of women). Moreover, inclusion of obesity in a logistic regression equation (data not shown) did not change the odds for the effect of sex. Thus the observed gender differences could not be attributed to obesity.

Our analysis could not explain the high inpatient mortality rate for women who undergo surgery for intact and ruptured AAA. The increased odds of death for women was similar for intact and ruptured AAA and was within the range of the higher risks (1.46 to 4.84) reported for women who have other cardiovascular operations, including coronary artery bypass[16] and heart transplantation.[17]

Earlier investigators found that gender was not related to operative mortality rates for coronary artery bypass if rates were adjusted for the smaller diameter of women's coronary arteries.[18] Given the relative large diameter of the aorta, it is very unlikely that vessel size plays a role in women's higher operative mortality rate for AAA surgery. Others have reported that women's lower survival after coronary artery bypass procedures was a result of their referral for surgery at a later stage of their disease.[19] In this regard, Sonesson and coworkers used age and body surface area to predict infrarenal aortic diameter in men and women.[20,21] They noted that at every age and body surface area women's aortas were smaller.

Table III. Effect of gender on preoperative death for ruptured AAA

	No. of patients		*Mortality rate*			
Variable	*Men*	*Women*	*Men*	*Women*	*Mortality ratio** *(95% CI)*	*p*
Age						
50-69 years	676	81	35.80	53.10	1.48 (1.18-1.86)	0.002
70 years or older	846	226	56.62	64.60	1.14 (1.02-1.28)	0.03
Comorbidities						
0-3	817	166	47.86	64.46	1.35 (1.18-1.54)	<0.001
4 or more	705	141	46.81	58.16	1.24 (1.06-1.46)	0.01
Year of surgery						
1980-84	570	99	48.07	54.55	1.13 (0.93-1.39)	0.23
1985-90	952	208	46.95	64.90	1.38 (1.23-1.56)	<0.001
Ischemic heart disease						
Yes	312	57	49.04	71.93	1.47 (1.20-1.79)	0.001
No	1210	250	46.94	59.20	1.26 (1.12-1.42)	<0.001
Renal failure						
Yes	278	64	69.78	71.88	1.03 (0.87-1.22)	0.74
No	1244	243	42.36	58.85	1.39 (1.23-1.57)	<0.001
Hypertension						
Yes	261	69	36.40	46.38	1.27 (0.94-1.72)	0.13
No	1261	238	49.64	65.97	1.33 (1.19-1.48)	<0.001
Dysrhythmia						
Yes	267	55	58.43	74.55	1.28 (1.06-1.53)	0.03
No	1255	252	45.02	58.73	1.30 (1.16-1.47)	<0.001
Hospital AAA surgical volume						
5 or more/year	744	143	43.15	58.74	1.36 (1.16-1.60)	0.001
1 to 4/year	778	164	51.41	64.02	1.25 (1.90-1.42)	0.003
All variables	1522	307	47.37	61.56	1.45 (1.10-1.90)†	0.008

*For individual variables, the statistic shown is a risk ratio that compares female to male mortality at the specified level of the variable.
†Odds ratio controlled by logistic regression for age, number of comorbidities, year of surgery, hospital surgical volume, and presence of ischemic heart disease, renal failure, hypertension, and dysrhythmias.

It is plausible that an AAA of the same size may represent more advanced disease in a woman compared with a man, and that reliance on AAA diameter as the primary indication for surgery has resulted in referral for surgery at a later stage of disease among women.

Controversy surrounds the optimal treatment for AAA, particularly of those in the range of 4 to 5 cm diameter[22,23] but also of larger aneurysms.[24,25] A number of anthropomorphic correlates have been used to relate aortic size to body size, including height, weight, body surface area, and size relative to other structures (for example, the 3rd lumbar vertebral body).[20,21] Use of objective criteria such as these to define risk and the need for surgery, instead of exclusive reliance on size, might reduce the gender-related mortality differences noted in this study.

The increasing perioperative mortality rate among women with ruptured AAA is particularly troubling especially because the increase was concentrated among younger women. It might be argued that this finding does not reflect a worsening risk for operation in women, but rather an increased index of suspicion for the diagnosis in women and improvements in emergency transportation. Both factors would result in more women surviving long enough to reach the operating room. However, if that were true, one would expect an increase in the population-adjusted rate of ruptured AAA in the 1985 to 1990 period, and this did not occur. Moreover, it is not likely that diagnostic and transportation improvements would disproportionately affect women. It should be noted that the 45% excess mortality risk associated with ruptured AAA in women may be an overestimate because odds ratios are less accurate when the outcome (death) is common. However, most of the stratified risk ratios, particularly the estimate of risk in the later years of the study, as well as the crude overall risk ratio of 1.3 (61.56/47.37) are close to the final 1.45 odds ratio (Table III).

Few other studies of AAA operative mortality data have included enough women to make statistically meaningful gender-related outcome assessments. One of the largest series, by the Canadian Society for Vascular Surgery,[2] reported no gender difference in operative mortality rate. However, that study covered only 9 months, included 154 women with 134 intact AAA and 20 ruptured AAA among 679 patients, and was not population-based. In addi-

Table IV. Results of logistic regression analysis of predictors of perioperative death for repair of ruptured AAA in 307 women and 1522 men, 1980 to 1990

	Regression Coefficient		*Odds Ratio*		*95% CI*		*p*	
Variable	*Men*	*Women*	*Men*	*Women*	*Men*	*Women*	*Men*	*Women*
Age	0.06	0.03	1.82†	1.35†	1.59-2.08	1.04-1.76	0.0001	0.02
Renal failure	1.28	0.95	3.60	2.56	2.64-4.90	1.29-5.19	0.0001	0.008
Dysrhythmia	0.73	0.82	2.08	2.27	1.55-2.78	1.09-4.72	0.0001	0.03
Hypertension	−0.43	−0.62	0.65	0.54	0.48-0.88	0.30-0.97	0.005	0.04
Cerebrovascular disease	0.19	1.98	1.21	7.24	0.61-2.39	1.38-38.15	0.58	0.02
Ischemic heart disease	0.16	1.07	1.17	2.92	0.89-1.55	1.41-6.01	0.26	0.004
Hospital AAA surgical volume	0.34	0.32	1.40	1.38	1.14-1.74	0.83-2.29	0.002	0.21
Comorbidities	−0.51	−1.09	0.60	0.34	0.46-0.77	0.18-0.62	0.0001	0.0004
Year of surgery	0.002	0.09	1.00*	2.44*	0.71-1.46	1.02-5.86	0.92	0.05

Variables used in the final logistic regression models were coded as follows: renal failure, dysrhythmia, hypertension, cerebrovascular disease, and ischemic heart disease: 0 = no, 1 = yes; hospital volume: 0 = 5 or more per year, 1 = 4 or fewer per year; comorbidities: 0 = 3 or fewer, 1 = 4 or more; year of surgery: 1 (1980) to 11 (1990).
*Comparing 1990 to 1980.
†Comparing age 81 with age 71 (mean age at rupture) in men and age 86 with age 76 in women.

tion, all procedures reported in that series were performed by members of the Canadian Society for Vascular Surgery, whose results may differ from those of surgeons in the general community. A recent study from the Cleveland Clinic also did not identify gender differences in early or late survival rates after surgery for AAA.[26] However, results such as these reflect the experience of a particular tertiary facility and cannot be extrapolated to the larger population. Moreover, 81% of the patients in the Cleveland Clinic series underwent coronary artery angiography with aggressive treatment of significant coronary disease before surgery for their AAA, and the mortality risk accompanying this treatment was not considered in assessing gender-related mortality differences. A New York State study that examined 3 years' experience and included 778 women among 3570 elective AAA repairs reported a 15% increased risk of operative death for women, although this difference was not statistically significant.[1] The current Michigan study covered 11 years, had twice as many patients, and possessed proportionately greater power to find gender differences.

The use of large administrative databases for mortality studies has the advantages of large numbers, completeness, and consistency. However, they also have well-recognized limitations. Because the database did not include personal identifiers, we could not exclude multiple admissions of the same patient. This limitation may have inflated AAA prevalence estimates, particularly in the early years of the study when separate admissions for diagnostic studies and subsequent operation were more common. This also could have resulted in an underestimate of elective AAA mortality rates, because a patient who was discharged after AAA repair and readmitted a few days or weeks later with a fatal myocardial infarction would not be classified as a surgical fatality.

The database's use of ICD-9 codes to represent diagnoses and procedures is also likely to introduce error. A recent study of the accuracy of Medicare claims data found overall error rates of close to 25% in ICD-9 coding of principal diagnoses and principal procedures, but with some significant exceptions.[27] Coding for repair of AAA as a principal or secondary procedure was found to be highly reliable, with sensitivity and predictive value of 100% (95% CI, 77% to 100%) and 93% (95% CI, 68% to 100%), respectively. The predictor variables of primary concern in this study-age, gender, and dates of admission and discharge-also have been found to be very accurate.[28] Coding of comorbidities is less accurate and is subject to limitations that are inherent in the use of administrative databases.[29] The effect of this would be to reduce the strength of any true association between a comorbidity and death. Therefore, the associations noted in this study are likely to represent the minimum effect of comorbidities, and control of their confounding effects by logistic regression was incomplete.

Because coding forms for the Michigan Inpatient Data Base permit a maximum of seven diagnoses, and hospitals and physicians often code more on their own records, any gender-related bias in listing of AAA as a comorbidity on the data form would bias the denominators for the calculation of surgery rates.

For example, if men had more secondary diagnoses than women, their secondary AAA might not be selected for coding as often as women's, which would produce a spuriously high rate of AAA repair for men. However, approximately equal proportions of men and women had four or more comorbidities coded (42.6% of men, 46.2% of women), suggesting that differential coding cannot explain the apparent gender differences in management of AAA (Table I). Other limitations associated with use of ICD-9 codes include absence of information on severity of illness and important information such as the length of time between diagnosis and surgery of a ruptured AAA.

This study supports the existence of gender differences in the treatment of cardiovascular disease. In particular, it documents that women with intact and ruptured AAA were less likely to undergo operative repair than men and that women have a substantially higher mortality risk associated with aneurysm repair. Whether these findings are a result of clinical practice patterns or biologic factors remain to be determined, but gender differences of the magnitude observed in the present study are sufficient to justify a prospective investigation involving a regional or national cohort of patients.

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