The impact of gender on presentation, therapy, and mortality of abdominal aortic aneurysm in the United States, 2001-2004

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Introduction: **The elective repair of abdominal aortic aneurysms (AAA) may decrease a patient's risk of rupture and confers a significantly lower in-hospital mortality rate than emergency repair. Previous works have shown that AAA rupture rates are higher in women compared to men, and that women have higher associated in-hospital mortality rates. This study was performed to evaluate, currently, to what extent patient gender influences presentation and treatment of AAA and the associated outcomes in the United States.**

Methods: **The Nationwide Inpatient Sample was used, with pertinent ICD-9 codes, to identify all patient-discharges that occurred with the primary diagnosis of intact (iAAA) or ruptured/dissecting (rAAA) abdominal aortic aneurysms between the years 2001 and 2004. Univariate and multiple logistic regression analyses of variables were performed.**

Results: **An estimated 220,403 AAA patient-discharges were identified during the study period. 37,016 (17%) patients presented with rAAA. A higher percentage of women with AAA presented with rupture compared to men (21% vs 16%; odds ratio [OR] 1.40, 95% confidence interval [CI], 1.27-1.54). This rupture rate did not significantly change from 2001 to 2004 ($P = .85$ for trend). For iAAA, women had higher odds of in-hospital mortality than men (OR 1.60; 95% CI, 1.24-2.07). Compared to men, in-hospital mortality rates for women with iAAA were higher for both endovascular (2.1% vs 0.83%, $P < .0001$) and open repairs (6.1% vs 4.0%, $P < .0001$). For iAAA, fewer women underwent endovascular repair (32.4% vs 46.7%, $P < .0001$; O.R. 0.59, 95% CI, 0.52-0.67). For patients who presented with rAAA, women were less likely to undergo surgical intervention compared to men (59% vs 70%, $P < .0001$). For those that underwent repair, women had higher in-hospital mortality rates than men (43% vs 36%, $P < .0001$; OR 1.49, 95% CI, 1.16-1.91).**

Conclusion: **A higher percentage of women currently present with aneurysm rupture. They have higher in-hospital mortality rates for both iAAA and rAAA. This gender difference in the outcomes following repair of abdominal aortic aneurysm has persisted over time, the cause of which is not explained by these or previous data, a fact that warrants further investigation. (J Vasc Surg 2007;45:891-9.)**

It has been well documented that women have a higher risk of rupturing abdominal aortic aneurysms (AAA) compared to men.[1-4] Reasons may include the possibility that aneurysms of equal diameter may represent a greater proportional dilatation in women compared to men,[5] as well as the possibility that women experience an accelerated growth rate of AAA compared to men.[6]

Previous studies have recommended a lower threshold for intervention of AAA for women due to concerns about the demonstrated increased risk of rupture with its attendant mortality rates.[2,3,5,7] In 2003, this led to an official joint commission recommendation for a smaller threshold diameter of 4.5 to 5.0 cm for elective aneurysmorrhaphy in women.[8] Additionally, based on data from the previous two decades, it has been shown that for the repair of both intact (iAAA) and ruptured aneurysms (rAAA), women have substantially higher rates of in-hospital mortality.[2,9,10-14] More recently, using Medicare data, limited to patients over age 65, other authors have shown that these higher mortality rates for women have persisted over the last decade.[15,16]

These recommendations from the previous decade for earlier elective intervention in women with smaller aneurysms may have impacted the proportion of women with AAA that present with rupture. The objective of this study was to determine, during a period (2001-2004) in which an exclusive procedural code existed for endovascular aneurysm repair, and using a comprehensive nationally representative all-payer database, to what extent gender affects the presentation, treatment, and mortality for patients with abdominal aortic aneurysm.

METHODS

This is a retrospective population based study from administrative data obtained from the Nationwide Inpatient Sample (NIS) for the years 2001 to 2004. The NIS is the largest representative database of its kind.[17] The NIS uses a weighting strategy to allow national estimates to be calculated. Sampled hospitals are given appropriate weights based on the number of hospitals they represent in the database for a given year.[17] All data provided in the results section are reported in this "weighted" form. The diagnostic codes from the International Classification of Diseases

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Ninth Revision, Clinical Modification (ICD-9CM)[18] were used to identify all patient discharges with the principal diagnosis of intact AAA (441.4) or ruptured/dissecting AAA (441.3, 441.02). The cohort was further limited based on ICD-9CM procedural codes to identify those patients that underwent open aortic repair (OAR), (38.44, 39.25) or endovascular aortic repair (EVAR) (39.71). Because the ICD-9CM code specific to endovascular aortic repair was not available until October, 2000,[19] and the procedure could have previously been coded under a multitude of other nonspecific codes, for the purposes of homogeneity, the years prior to 2001 were excluded, as were patients under the age of 40.

The primary outcome measure was in-hospital mortality, regardless of length of time from the initial procedure. Secondary analyses included presentation type (iAAA vs rAAA) as well as type of repair performed (OAR vs EVAR). All data analyses were performed using the advanced survey procedures in SAS version 9.1 (SAS Institute, Cary, NC). Univariate analyses of categorical values were performed using the Rao-Scott χ^2 test, with a P value $< .05$ considered significant. Trend analyses were performed using the Mantel-Haenszel χ^2 test. Multiple logistic regressions were performed with presentation type, in-hospital mortality, and procedure type evaluated separately as dependent variables. Independent variables included in the regressions were: patient age, race, gender, insurance status, and selected patient comorbid medical conditions (congestive heart failure [CHF], renal failure, valvular heart disease, chronic lung disease, liver disease, hypertension, obesity, and diabetes mellitus).[20] In addition, certain hospital level characteristics including hospital teaching status, setting, and hospital geographic region were included in the multivariate logistic regression. These hospital level data are obtained from the American Hospital Association database, which is directly linked to the NIS by corresponding year.[17]

RESULTS

During the 4-year period of this study, an estimated 220,403 patient-discharges occurred for the principal diagnosis of abdominal aortic aneurysm in U.S. hospitals. The annual incidence of AAA overall as well as iAAA and rAAA remained nearly constant at approximately 55,000, 45,000 and 10,000, respectively per year, $P = .50$ for trend (Fig 1). Overall, 183,387 (83.2%) were treated for intact abdominal aortic aneurysms while 37,016 (16.8%) were treated for aneurysm rupture. Table I contains the patient characteristics based on presentation for intact vs ruptured AAA and includes the results of the univariate analysis of presentation type by each characteristic.

Intact AAA

Of those patients undergoing surgery for iAAA (n = 146,684), the mean age was 72.3 (SEM 0.07), 80% were men, and 91% were white. Overall 40.6% of patients with iAAA were treated by endovascular means during the studied interval. There was an increasing trend in the usage of EVAR from 33% in 2001 to 50% by 2004, $P < .0001$ for trend (Fig 2).

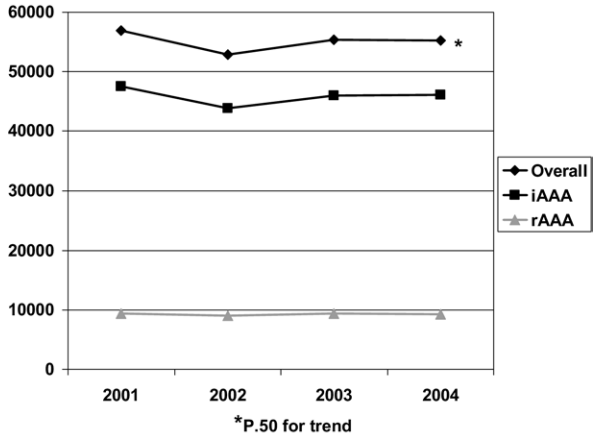

Fig 1. This line graph demonstrates the overall annual incidence of AAA as well as that for the intact and ruptured subgroups in the United States, 2001-2004.

Overall, in-hospital mortality was 3.1%. Open repair (4.5%) conferred a higher mortality rate than endovascular repair (1.0%) by univariate analysis, $P < .0001$ (Table II). Of note, crude in-hospital mortality for iAAA was also significantly greater for women, older patients, non-white patients and those undergoing surgery in 2001 vs 2004 (Table II). By multivariate analysis, with patient death as the dependent variable, factors independently predictive of higher in-hospital mortality included; open repair (odds ratio [OR] 3.68; 95% confidence interval [CI], 2.56-5.31), female gender (OR 1.60; 95% CI, 1.24-2.07) non-white race (1.52; 95% CI, 1.08-2.14), older patient age, and pre-existing renal failure, congestive heart failure, or liver disease (Table III).

Patient gender. Table IV contains a comparison of patient characteristics by gender for the iAAA surgical patients. For intact AAA, women had higher overall mortality rates compared to men, 4.8 vs 2.6%, $P < .0001$. This was true for both open and endovascular procedures. By univariate analysis, for OAR, the mortality rate was higher for women compared to men, 6.1 vs 4.0%, $P < .0001$; as well as EVAR, 2.1% vs 0.83%, $P < .0001$. On average, women were 2 years older than men. They had higher rates of chronic lung disease (40.4% vs 32.6%, $P < .0001$) and hypertension (60.6% vs 56.6%, $P < .0001$); however, they were similar in rates of valvular heart disease, congestive heart failure, and renal failure, the three comorbidities that were independently predictive of higher in-hospital mortality on multivariate analysis. In the multivariate logistic regression for mortality of iAAA, the odds of mortality in women was 1.6 (95% CI, 1.24-2.07) times that of men despite adjustment for age, race, procedure type (OAR vs EVAR), hospital teaching type, year of surgery and medical comorbidities (Table III). During the course of the study, for iAAA,

Table I. Characteristics of all AAA patients by presentation type (iAAA vs rAAA); results of univariate analysis included

	Intact (%)	*Ruptured (%)*	P *value*
No. patients	183,387 (83.2)	37,016 (16.8)	
Patient gender			<.0001
Men	143,377 (78.2)	26,319 (71.1)	
Women	39,961 (21.8)	10,698 (28.9)	
Mean age [SEM]	72.7 [0.07]	73.2 [0.16]	<.0001
Men [SEM]	72.2 [0.08]	71.9 [0.18]	<.0001
Women [SEM]	74.5 [0.11]	76.2 [0.27]	<.0001
Median age for men	73	73	
Median age for women	75	78	
Patient race			<.0001
White	120,735 (89.3)	22,522 (84.3)	
Non-white	14,477 (10.7)	4,182 (15.7)	
Insurance			<.0001
Private/Medicare	178,594 (96.4)	34,375 (93.0)	
Medicaid/self-pay	6,640 (3.6)	2,598 (7.0)	
Comorbidities			
Diabetes	21,953 (12.0)	3,694 (10.0)	<.0001
Congestive heart failure	3,757 (2.0)	2,057 (5.6)	<.0001
Renal failure	7,799 (4.3)	2,670 (7.2)	<.0001
Chronic lung disease	62,127 (33.9)	11,025 (29.8)	<.0001
Hypertension	104,281 (56.9)	16,144 (43.6)	<.0001
Liver disease	1,634 (.89)	325 (.88)	.91
Obesity	6,552 (3.6)	1,208 (3.3)	.21
Valvular heart disease	1,799 (0.98)	976 (2.6)	<.0001

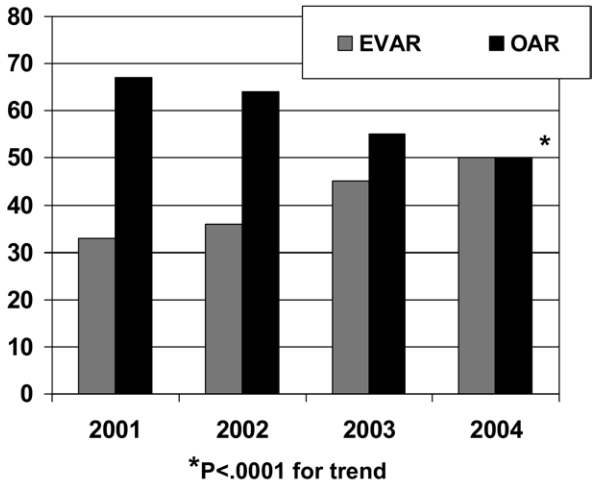

Fig 2. This bar chart demonstrates the shift in the percentage of intact AAA cases performed endoluminally from 2001-2004. By 2004, 50% of cases were endovascular aortic repairs.

the overall in-hospital mortality decreased from 3.5% in 2001 to 2.6% in 2004, $P < .0001$ for trend. The in-hospital mortality rate for men decreased from 3.1% to 2.2%, $P < .0001$ for trend. During the same interval, the mortality rate for women also decreased, but to less of a degree going from 5.2% in the year 2001 to 4.2% in 2004, $P = .003$ for trend (Fig 3). In terms of operative intervention for iAAA, women were less likely to undergo EVAR compared to men (32.4% vs 46.7 %, $P < .0001$). This was confirmed in a separate multivariate logistic regression in which women had odds of EVAR 0.59 times that of men (95% CI, 0.52-0.67).

Table II. Univariate analysis of in-hospital mortality for operative patients

	iAAA		*rAAA*	
Factor	*% Mortality*	P *value*	*% Mortality*	P *value*
Overall	3.1		37.3	
Gender		<.0001		<.0001
Men	2.6		35.6	
Women	4.8		43.0	
Age groups (y)		<.0001		<.0001
<60	.73		20.8	
60-69	1.7		28.8	
≥ 70	3.9		43.2	
Patient race		.001		.41
Non-white	4.3		36.6	
White	3.0		38.8	
Patient insurance type		.18		.053
Private	3.1		37.7	
Medicaid/self-pay	2.4		31.4	
Year of surgery		.033		.12
2001	3.5		37.7	
2002	3.1		40.0	
2003	3.0		34.8	
2004	2.6		36.3	
Procedure type		<.0001		.0002
OAR	4.5		38.2	
EVAR	1.0		29.0	

Ruptured AAA

Of the patients that presented with rAAA, 68% underwent operative management. The operative group had an

Table III. Multivariate analysis of in-hospital mortality for iAAA and rAAA

	iAAA		*rAAA*	
Factor	*Odds ratio*	*95% Confidence interval*	*Odds ratio*	*95% Confidence interval*
Sex				
Women (vs men)	1.60	1.24-2.07	1.49	1.16-1.91
Age group				
≥70 (vs <60)	9.20	3.22-26.3	4.01	2.59-6.22
≥70 (vs 60-69)	2.11	1.55-2.86	2.03	1.53-2.70
Insurance type				
Medicaid/self-pay (vs private)	0.90	.44-1.85	1.73	1.13-2.67
Procedure type				
OAR (vs EVAR)	3.68	2.56-5.31	1.19	.805-1.77
Race				
Non-white (vs white)	1.52	1.08-2.14	1.00	.708-1.42
Hospital teaching status				
Non-teaching (vs teaching)	.99	.785-1.24	1.12	.885-1.40
Year of surgery				
2001 (vs 2004)	1.61	.357-7.25	1.06	.514-2.20
2002 (vs 2004)	1.58	.353-7.05	1.08	.514-2.28
2003 (vs 2004)	.617	.050-7.62	1.05	.347-3.20
Comorbid conditions				
Congestive heart failure (vs none)	7.77	4.17-14.5	.774	.382-1.57
Hypertension (vs none)	0.35	.272-.450	.566	.458-.699
Chronic lung disease (vs none)	1.13	.901-1.42	.578	.464-.720
Valvular heart disease (vs none)	2.04	.258-16.1	.709	.123-4.08
Liver disease (vs none)	4.26	1.93-9.39	5.07	1.77-14.5
Renal failure (vs none)	2.97	2.12-4.15	.906	.592-1.39
Diabetes (vs none)	1.00	.709-1.42	1.16	.801-1.69
Obesity (vs none)	1.03	.481-2.19	1.03	.587-1.81

Table IV. Intact AAA surgical patient characteristics by gender (P value represents men vs women)

Factor	*Men*	*Women*	*Overall*	P *value*
No. patients (%)	117,306 (80.0)	29,377 (20.0)	146,684	
Mean age [SEM]	71.9 [0.08]	73.9 [0.12]	72.3 [0.07]	<.0001
Race				
% Non-white	9.10	10.9	9.50	.0015
% White	90.9	89.1	90.5	
Insurance type				
% Private/HMO	96.8	96.7	96.8	.68
% Medicaid/self-pay	3.20	3.30	3.20	
Repair type				<.0001
% OAR	57.3	67.6	59.4	
% EVAR	46.7	32.4	40.6	
In-hospital mortality				
% Overall	2.6	4.8	3.1	<.0001
% EVAR	0.83	2.1	1.0	<.0001
% OAR	4.0	6.1	4.5	<.0001
Hospital type				.47
% Teaching	57.7	57.1	57.6	
% Non-teaching	42.3	42.9	42.4	
Comorbidities				
% Diabetes	12.4	9.9	11.9	<.0001
% Obesity	3.8	3.9	3.8	.62
% Congestive heart failure	0.40	0.53	0.43	.19
% Renal failure	3.9	3.4	3.8	.08
% Chronic lung disease	32.6	40.4	34.2	<.0001
% Hypertension	56.6	60.6	57.4	<.0001
% Liver disease	0.89	0.70	0.86	.14
% Valvular heart disease	.08	.12	.09	.27

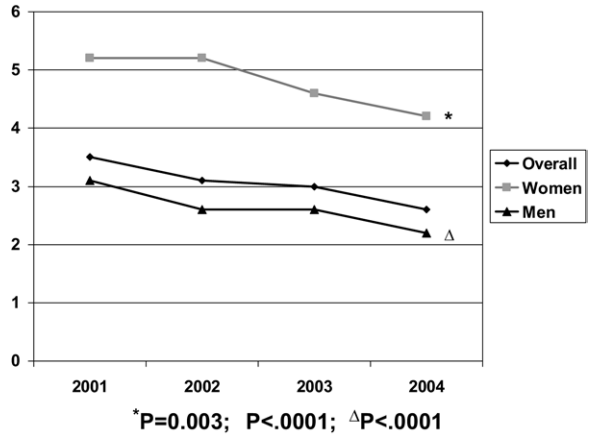

Fig 3. This graph demonstrates the annual in-hospital mortality rate for intact AAA overall, as well as that for women and men individually from 2001-2004. The mortality rates have decreased overall, as well as for both genders, however, the rate for women remained >4% in 2004.

associated in-hospital mortality rate of 37.3%. Of those taken to surgery, 90% underwent open repair while 10% underwent endovascular repair. The percentage of procedures performed endoluminally increased from 6.2% in 2001 to 14.3% by 2004, $P < .0001$ for trend. Of all patients treated surgically for rAAA, the mean age was 72.3 years (SEM = 0.16), 78% were men, and 88% were white (Table V).

On univariate analysis for rAAA mortality, the proportion was significantly higher for women, older patients, and patients undergoing open repair (Table II). Multivariate analysis of mortality for the rAAA patients, seen in Table III, revealed factors independently predictive of higher odds of mortality for rAAA included female gender with odds ratio 1.49 (95% CI, 1.16-1.91), and age ≥70 years with an odds ratio 2.11 (95% CI, 1.55-2.86) compared with those 60 to 69 years of age.

The univariate factors affecting AAA presentation type showed that a greater percentage of the following patient groups presented with aneurysm rupture: women, those without private insurance, non-white patients, and those with a history of CHF, renal failure, or valvular heart disease (Table I). By multivariate analysis, the following remained independently predictive of presenting with aneurysm rupture: female gender, the lack of private insurance, non-white patients, and the presence of CHF, renal failure, or valvular heart disease (Table VI).

Patient gender. Of the men that presented with the principal diagnosis of AAA, 15.5% presented with rupture. By comparison, 21.1% of women presented with rupture ($P < .0001$). Overall, women made up 23% of patients with AAA, but represented a higher proportion of all patients treated for rupture at 28.9% ($P < .0001$). These proportions did not change over the 4- year period; of the women with AAA, >20 % consistently presented with rupture, $P = .85$ for by trend test (Fig 4). By multivariate analysis of AAA presentation (ruptured vs intact), women had odds of presenting with rupture 1.4 times that of men (95% CI, 1.27-1.54).

Of those that presented with a principal diagnosis of rAAA, women were less likely to undergo surgical intervention compared to men (59% vs 70%, $P < .0001$). This also remained significant in the multivariate analysis in which men were 1.4 times more likely to undergo surgical intervention for rAAA compared to women (95% CI, 1.08-1.71). For those that did undergo treatment for rAAA, overall in-hospital mortality was greater for women (43% vs 35.6%, $P < .0001$). As shown in Table III, in the multivariate logistic regression analysis for rAAA, after adjustment for age, race, insurance, medical comorbidities as well as hospital type, women had odds of mortality 1.49 that of men (95% CI, 1.16-1.91).

DISCUSSION

Using data obtained from the Nationwide Inpatient Sample for the years 2001-2004, the current work has shown that, currently, despite an essentially unchanged annual incidence in the number of patients treated for abdominal aortic aneurysm, a higher proportion of women with AAA present with rupture and continue to have overall increased adjusted in-hospital mortality than men for iAAA and rAAA (OR ≈ 1.5 for both). While an increasing percentage of patients are undergoing EVAR over time, which was associated with a significantly lower in-hospital mortality rate, women are less likely to undergo endovascular repair of their intact AAA.

The observed lower overall in-hospital mortality rate for EVAR (1.0%) compared to OAR (4.5%) $P < .0001$ for iAAA agrees with the findings of previous trials comparing the two procedures. Notably in 2004, the investigators of two randomized controlled trials found similar 30 day mortality rates. The EVAR-1 trial reported significantly lower 30 day mortality rates for EVAR (1.7%) compared to open AAA repair (4.7%).[21] These findings were confirmed by the DREAM trial participants, who reported similar mortality rates of 1.2% in the EVAR group and 4.6% in the open repair group.[22] Of note, the current work evaluates in-hospital mortality, which may underestimate overall 30 day mortality rates, due to lack of follow-up data.

The demonstrated higher in-hospital mortality rate for women with AAA in this study agrees with the findings of several previous works.[2,9-16] Katz et al, using the Michigan Inpatient Database in 1997, demonstrated a clear discrepancy in operative mortality rates for men and women for both intact and ruptured AAA. They concluded that the data could not explain this difference but offered that a delay in referral due to reliance on AAA diameter as the universal indicator for surgery may be an important factor.[2] Similarly, in 2001, Huber et al, published data from the NIS (1994-1996) showing an increased mortality rate for women as well, citing data for a potentially higher, unmeasured, percentage of juxtarenal aneurysms in the female population as one possible explanation.[10,23,24] The gender-related differences in mortality outcomes observed

Table V. Ruptured AAA surgical patient characteristics by gender (P values represent men vs women)

	Men	*Women*	*Overall*	P *value*
No. patients (%)	16,230 (77.5)	4,703 (22.5)	20,932 (100)	
Mean age [SEM]	71.6 [0.18]	74.8 [0.31]	72.3 [.16]	<.0001
Race				
% Non-white	12.3	15.5	13.0	.042
% White	87.7	84.5	87.0	
Insurance type				
% Private/HMO	93.3	94.5	93.6	.23
% Medicaid/self-pay	6.7	5.5	6.4	
Repair type				.78
% OAR	89.9	90.3	90.0	
% EVAR	10.1	9.7	10.0	
In-hospital mortality				
% Overall	35.6	43.0	37.3	<.0001
% EVAR	29.4	27.7	29.0	.75
% OAR	36.3	44.7	38.2	<.0001
Comorbidities				
% Diabetes	8.6	10.1	8.9	.17
% Obesity	3.6	3.0	3.5	.34
% Congestive heart failure	2.0	2.3	2.1	.54
% Renal failure	7.4	5.7	7.0	.08
% Chronic lung disease	32.0	34.4	32.6	.17
% Hypertension	38.0	46.3	39.9	<.0001
% Liver disease	1.0	.75	.96	.44
% Valvular heart disease	0.45	0.51	0.47	.82

Table VI. Multivariate analysis of the presentation of ruptured AAA

Factor	*Odds ratio*	*95% Confidence interval*
Gender		
Women (vs Men)	1.40	1.27-1.54
Age group		
<60 (vs ≥70)	1.67	1.43-1.96
60-69 (vs ≥70)	0.87	.78-.97
Insurance type		
Medicaid/self-pay (vs private)	1.72	1.41-2.10
Race		
Non-white (vs white)	1.47	1.25-1.73
Hospital teaching status		
Non-teaching (vs teaching)	1.41	1.22-1.62
Comorbid conditions		
Congestive heart failure (vs none)	2.44	1.94-3.10
Hypertension (vs none)	0.61	0.55-0.67
Chronic lung disease (vs none)	0.86	0.78-0.95
Valvular heart disease (vs none)	1.94	1.39-2.71
Liver disease (vs none)	0.95	0.61-1.49
Renal failure (vs none)	1.29	1.07-1.56
Diabetes (vs none)	0.87	0.75-1.01

in the current study are not readily explained by the data. While women, on average, were older than men for both iAAA and rAAA, and age was an independently predictive of higher mortality rates for both groups, patient age was included in the multivariate logistic regression. Compared to men, women had similar rates of congestive heart failure and renal failure as well as slightly higher rates of hypertension and chronic lung disease however, patient medical comorbid conditions were also included in the multivariate logistic regression of in-hospital mortality, which confirmed female gender as an independent risk factor for mortality after aneurysm repair.

We exclusively utilized the years 2001 to 2004 for this study. During this time, a specific ICD-9CM code (397.1) existed for endovascular aortic repair. Treatment by EVAR was independently predictive of decreased mortality on multivariate analysis for iAAA mortality. Based on these data, the limitation of access to endovascular technology observed for women (32.4% vs 42.7%, $P < .0001$) is a factor that may have contributed to their increased overall mortality rate for iAAA compared to men (4.8% vs 2.6%, $P < .0001$). The underlying cause for the lower proportion of women treated by EVAR may be purely anatomical; the relatively large diameter of the delivery sheaths may preclude the use of these devices in the generally smaller native access vessels of the female population.[25,26] However despite this anatomical constraint, some single institution reports have shown that while complications arising from endoluminal treatments may be more common in women vs men,[27] major outcome indicators such as all-cause mortality and major complications are equivalent with follow-up intervals as long as 5 years.[28-30] Hopefully, the knowledge of the results of the current work as well as previous works will serve as an impetus for a focus of research to develop smaller delivery devices specifically for women with abdominal aortic aneurysms, helping to narrow the gender gap in terms of EVAR eligibility and overall in-hospital mortality and access-related morbidity for iAAA.

Our finding that women have a proportionally higher risk of rupture for AAA is similar to that found in other

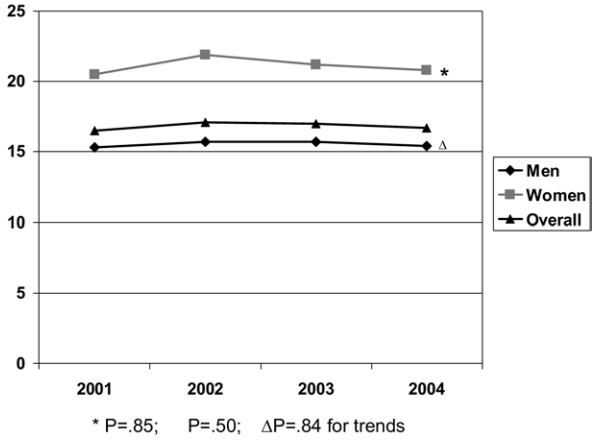

Fig 4. This figure represents the percentage of aneurysms that presented with rupture from 2001-2004 by patient gender. No significant change occurred for either gender, with the proportion of women with AAA presenting with rupture remaining >20% each year.

works.[1-5,15,16] In 1999, using data obtained from the UK small aneurysm trial, Brown et al reported that women have a relative risk of rupture three times that of men.[1] These findings were cited in the 2003 recommendation by the Joint Council of the American Association for Vascular Surgery and Society for Vascular Surgery, which stated for women with AAA, elective repair should be considered for aneurysms 4.5 to 5.0 cm in diameter.[8] These findings were further corroborated by Dillavou et al in 2006, based on administrative data from the Centers for Medicare Services, which included the years 2000 to 2003,[15,16] but was limited to a cohort of single payer patients over 65 years. Our findings, from a larger dataset which includes patients under the age of 65 (20% of the total) and, which includes uninsured patients (5% of total) independently confirms those results. Recently, some institutionally based studies, though limited by total patient number, have reported on the increased rupture risk for women, concluding that AAA of equal diameter may represent a greater proportional dilatation in women,[5] and that women possibly experience an increased growth rate of their AAA.[6]

In the current work, we proposed that the dissemination of the knowledge about the recommendations of previous studies dating back to the mid 1990s, ie, the importance of earlier intervention in women with AAA may have impacted the rate at which women present with rupture over time. In practice, if women were being referred earlier for repair of smaller aneurysms, one may expect the national proportion of those presenting with rupture to decrease over time in relation to those undergoing intact AAA repair. The results of this study show that the proportion of women that presented with rupture did not decrease over the 4-year interval. Instead, the proportion of women presenting with rAAA remained persistently >20% while that for men remained nearly static at approximately 16%. These findings extend those found by Dillavou et al through 2003,[15,16] with the current work encompassing the most recent available data shows this trend continues through 2004. The etiology of this gender outcomes discrepancy is impossible to prove based on the administrative nature of these datasets. One explanation we offer may include a possible disconnect between the knowledge base of the vascular surgical and that of the referring medical community[31] in regard to the importance of these and other results. Regardless, continued efforts should be made to communicate this information to the primary care medical community to ensure early referral when an aneurysm of any dimension is detected in a woman.

One notable gender difference in AAA management that could potentially impact the difference in rupture rates as well as overall mortality rates is that currently no national screening recommendations exist for women. Screening trials performed in men have shown to decrease rupture risk by 50%[32] and decrease the need for emergency operations by 68%.[33] Recommendations have been made to screen men aged 65 to 75 as a means of reducing AAA-related mortality in the United States,[34] and similar results were found by subgroup analysis in Western Australia.[35] To our knowledge, only one randomized trial dedicated to aneurysm screening in women has been performed.[36] Scott et al, in a 2002 British study (n = 9342), concluded that screening conferred no overall benefit as the incidence of rupture was equivalent for those that were screened and those that were not.[36] Of note, the criteria for surgical intervention in that study may not be generalizable to the US population, which typically recommends undergoing elective repair at a smaller diameter.[8] Other authors have advocated initiating screening programs in women. Recently, Wanhainen et al, utilizing a Markov simulation model, determined that the cost-effectiveness ratio of screening women, in terms of cost per life year gained was equivalent to that of men, with the lower prevalence of AAA in women being offset by the increased rupture risk[37] concluding that women should be included in future AAA screening studies. Longo et al found screening women who were at higher risk such as smokers or those with a positive family history of AAA may be beneficial.[38] In light of these findings, a US based randomized screening trial dedicated to women could be helpful and may ultimately prove cost-effective.[37]

An additional unmeasured factor that may be limiting access to timely surgical intervention for AAA in women may be a gender bias at the referring physician and intervening physician level. A significant gender bias against women has been identified in terms of access to diagnostic coronary angiography as well as percutaneous and surgical revascularization for women with coronary artery disease.[39] Because this bias has been identified in the cardiac surgical arena, and due to the similarity of patient populations, gender bias warrants consideration in the vascular surgery discipline as well.

The limitations of administratively abstracted data are well known, specifically in terms of the lack of information on the severity of coded medical comorbidities and patient

case mix.[40] Additionally, some sampled hospitals do not report information on race, which may lead to missing and inaccurate data. In this study, the observation that nonwhite patients presented with increased rupture rates and had increased mortality rates for iAAA is qualified by the fact that, of the total patient cohort, race data was not available for 25% of patients. Further studies with more complete data for those factors should be pursued to make more accurate conclusions based on these findings. Similarly, there is no information on patient stage of disease in the NIS. In this study, aneurysm size, morphology, and anatomical location are unknown, which are clearly important factors when evaluating the presentation of ruptured or asymptomatic aneurysms as well as vascular surgical interventions and outcomes, particularly in the case of access to endovascular modalities. The outcome measure of in-hospital mortality is also a limited measure of overall success. Ideally, 30 day mortality and all cause mortality as well as major morbidity and postoperative complications should be evaluated; however, they are unavailable in this database. The main focus of this study was to evaluate the effect of patient gender on presentation type, surgical intervention, and in-hospital mortality as it relates to the period in which an exclusive endovascular aortic repair ICD-9CM code existed; all of which are variables more reliably coded in the NIS from 2001to 2004.

CONCLUSION

In conclusion, we have added further evidence that through 2004, women are still more likely to present with ruptured abdominal aortic aneurysm compared to men. This proportion has not decreased with time despite published recommendations, including those by major vascular societies, to intervene at a lower AAA size threshold for women with this disease.[8] Additionally, women continue to have higher in-hospital mortality rates for ruptured AAA, as well as for open and endovascular repair of iAAA, which may have implications if more elective cases are performed for smaller aneurysms in the future. The causal factors underlying the effect of gender on mortality are not clearly explained by the current or previous data, a fact that warrants further study. [29]

AUTHOR CONTRIBUTIONS

Conception and design: JM, ME
Analysis and interpretation: JM, JH, ME
Data collection: JM
Writing the article: JM
Critical revision of the article: JH, ME
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