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Sex Differences in Procedure Selection and Outcomes of Patients Undergoing Mitral Valve Surgery

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ABSTRACT

Background: There is a paucity of data on sex differences in procedure selection and outcomes of patients undergoing mitral valve surgery.

Methods and Results: The National Inpatient Sample database from 2005 to 2008 was searched to identify patients ≥30 years of age who underwent mitral valve repair or replacement (ICD-9-CM codes 35.12, 35.23, and 35.24). Women constituted 51.6% of the patients, and they were older, were less affluent, had higher values for the Charlson comorbidity index, and more often presented on an urgent/emergent basis. Women underwent repair less often than men (37.9% versus 55.9%, $P < .001$) and more often underwent concomitant tricuspid surgery or a Maze procedure. After adjustment for propensity scores, women were more likely to undergo replacement (odds ratio, 1.78; 95% confidence interval, 1.64-1.93; $P = .0001$), they had longer lengths of stay, and less favorable disposition. Among the patients who underwent mitral valve repair, women had a higher hospital mortality (2.06% versus 1.36%, $P = .0328$). After adjustment for propensity scores and concomitant procedures, this relationship was no longer statistically significant.

Conclusions: Women are less likely than men to receive mitral valve repair. Although the higher hospital mortality of women presenting for mitral valve surgery was accounted for by their worse preoperative profiles, this sex disparity reflects the current reality in surgical practice and identifies an important area for future improvement in the care of patients with valvular heart disease.

INTRODUCTION

Sex has been identified as an independent predictor of adverse outcomes after coronary artery bypass grafting (CABG) surgery [Vaccarino 2002; Blankstein 2005; Bukkapatnam 2010]. Koch et al [2003] suggested that differences in mortality and morbidity between men and women undergoing CABG can be explained by markedly different preoperative profiles; therefore, after adjustment for baseline characteristics, sex no longer affects those outcomes. With respect to valve surgery, mortality does not appear to be influenced by sex in the subset of patients who undergo isolated aortic valve replacement [Aranki 1993; Duncan 2006]. Few studies have addressed the impact of sex on the outcomes of patients undergoing mitral valve surgery [Song 2008]. Furthermore, there is a paucity of data on the impact of sex on the type of mitral valve procedure performed. This lack of data is of importance, considering the established superiority of mitral valve repair over replacement with respect to short-term and long-term survival, preservation of ventricular function, and valve-related complications [Perier 1984; Grossi 1998]. Using the largest all-payer database in the United States, we examined whether the type of mitral valve procedure performed was influenced by sex and whether any sex differences exist in the short-term outcomes of patients undergoing mitral valve repair or replacement.

MATERIALS AND METHODS

Database

The Nationwide Inpatient Sample (NIS) is a stratified probability sample of inpatient discharges that includes data on approximately 20% of hospital admissions in the United States. Sampling bias is minimized in the NIS by stratification by geographic region, urban versus rural location, teaching status, and hospital bed size. The database is compiled by the Healthcare Cost and Utilization Project (HCUP) and funded by the Agency for Healthcare Research and Quality. It contains deidentified patient data, including up to 15 procedure codes and 15 diagnostic codes according to the International Classification of Diseases, Ninth Edition, Clinical Modification (ICD-9-CM). The NIS is the largest all-payer database and is used for the analysis of trends in health care utilization, access, charges, quality, and outcomes, for both research and policy making [Varadarajulu 2006]. The study was approved by our institutional review board.

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Table 1. Baseline Characteristics of Patients Stratified by Mitral Valve Procedure

	Overall			Mitral Valve Repair			Mitral Valve Replacement		
	Male	Female	*P*	Male	Female	*P*	Male	Female	*P*
Patients, n	31,060 (48.7%)	32,694 (51.3%)		17,355 (58.4%)	12,379 (41.6%)		13,705 (40.3%)	20,315 (59.7%)	
Age, y*	60.5, 60 (51-70)	63.3, 65 (54-74)	.0001	59.5, 59 (51-68)	63.4, 65 (54-74)	.0001	61.9, 62 (53-72)	63.2, 65 (53-74)	.0001
Age ≥65 y	39.0%	51.0%	.0001	34.7%	50.7%	.0001	44.5%	51.2%	.0001
White	80.9%	74.0%	.0001	83.3%	78.6%	.0001	78.0%	71.2%	.0001
Urban	84.0%	83.7%	.6449	85.8%	86.3%	.6492	81.8%	82.1%	.7381
Medicare	37.8%	52.7%	.0001	32.0%	49.4%	.0001	45.2%	54.7%	.0001
Medicaid	5.0%	7.6%	.0001	3.1%	5.0%	.0001	7.4%	9.2%	.0077
Income									
Quartile 1	18.3%	22.9%	.0001	14.6%	18.0%	.0010	23.0%	25.9%	.0032
Quartile 2	21.7%	24.0%		19.7%	21.2%		24.3%	25.7%	
Quartile 3	26.8%	25.7%		27.4%	27.0%		26.0%	24.9%	
Quartile 4	33.2%	27.4%		38.3%	33.8%		26.6%	23.5%	
Admission status									
Elective	68.4%	63.9%	.0001	76.4%	72.2%	.0004	58.5%	58.9%	.7810
Urgent/emergent	31.6%	36.1%		23.6%	27.8%		41.5%	41.1%	
Charlson index*	0.94, 1 (0-1)	1.12, 1 (0-2)	.0001	0.75, 0 (0-1)	0.93, 1 (0-1)	.0001	1.19, 1 (0-2)	1.23, 1 (0-2)	.1466

*Data are presented as the mean, median (interquartile range).

Sample Selection

We identified patients who underwent mitral valve repair or replacement (ICD-9-CM codes 35.12, 35.23, 35.24) by using discharge data from 2005 to 2008 from the NIS, HCUP, Agency for Healthcare Research and Quality. Patients <30 years old were excluded, as were those who underwent closed-heart valvuloplasty (ICD-9-CM code 35.0), congenital heart disease (ICD-9-CM codes 35.34, 35.35, 35.39, 35.4, 35.53, 35.54, 35.62, 35.63, 35.72, 35.73, 35.8, 35.9, 39.0, 39.21), coronary revascularization (ICD-9-CM codes 36.1, 36.2, 36.3, 36.9), excision of ventricular aneurysm (ICD-9-CM codes 37.32, 37.35), replacement of the thoracic aorta (ICD-9--CM code 38.45), aortic fenestration procedure (ICD-9-CM code 39.54), and other valvular repair or replacement (except tricuspid valve) procedures (ICD-9-CM codes 35.10, 35.11, 35.13, 35.20, 35.21, 35.22, 35.25, 35.26, 35.27, 35.28, 35.33). Specifically, patients with concomitant tricuspid valve repair or replacement and atrial septal defect/patent foramen ovale closure were not excluded from the analysis. Men and women were compared with respect to the following baseline characteristics: age, race, urban-rural residency, insurance type, income, admission status, and the Charlson comorbidity index. The main outcomes of interest included type of mitral valve procedure (repair versus replacement), concomitant procedures (Maze, tricuspid valve repair or replacement), in-hospital death, length of stay (LOS), and discharge location.

Statistical Analysis

Chi-square tests of independence and independent-groups Student *t* tests were used to compare the groups with respect to baseline characteristics. Descriptive statistics, including percentages, means, medians, and interquartile ranges, are reported. LOS was initially examined as a continuous outcome, but because of its skewed distribution, it was subsequently dichotomized with a median split. These data are presented in this manner throughout this report. Initial comparisons were made across all individuals who underwent mitral valve repair or replacement. Subsequent stratified analyses were performed separately for patients who underwent mitral valve repair and for those who underwent mitral valve replacement. In an effort to assess the influence of baseline differences between men and women, we used logistic regression to examine the relationship between sex and each of the outcomes. Odds ratios and their corresponding 95% confidence intervals are reported for women relative to men. Propensity scores were generated to balance men and women with respect to the following baseline characteristics: age, urban residency, Medicare and Medicaid status, income quartile, admission status, and the Charlson comorbidity index. Logistic regression was then used to compare men and women with respect to the likelihood of undergoing mitral valve replacement after adjusting for the calculated propensity scores. When examining the relationship between sex and each of the outcomes from the stratified analyses, we computed adjusted odds ratios after (1) controlling for propensity score and (2) controlling for the propensity scores as well as the presence of the concomitant Maze, tricuspid valve repair, and tricuspid valve replacement procedures. Results were considered statistically significant for *P* values <.05. All analyses were performed with SAS version 9.2 (SAS Institute,

Table 2. Operative Data*

	Overall			Mitral Valve Repair			Mitral Valve Replacement		
Concomitant Procedures	Male	Female	*P*	Male	Female	*P*	Male	Female	*P*
Maze	24.1%	28.2%	.0001	23.9%	26.9%	.0081	24.3%	29.0%	.0001
Tricuspid repair	4.4%	9.4%	.0001	4.6%	11.4%	.0001	4.3%	8.2%	.0001
Tricuspid replacement	0.8%	1.5%	.0001	<0.3%†	<0.4%†	.0826	1.6%	2.1%	.1262
IABP	5.0%	5.0%	.9696	2.6%	2.9%	.3997	8.0%	6.2%	.0031
Pacemaker	8.3%	10.3%	.0001	5.4%	7.0%	.0033	11.9%	12.3%	.6463

*IABP indicates intra-aortic balloon pump.

†Actual rate unreportable per Healthcare Cost and Utilization Project (HCUP) Nationwide Inpatient Sample guidelines.

Cary, NC, USA) and the appropriate weighting to reflect the stratified sampling scheme used in the NIS.

RESULTS

Baseline Characteristics

Men and women differed significantly with respect to several aspects of their preoperative profiles (Table 1). Women constituted 51.3% (32,694/63,754) of the patients. Women presented for mitral valve surgery at an older median age (65 years versus 60 years, $P = .0001$). In addition, 51% of the women were ≥65 years old at presentation, compared with 39% of men ($P = .0001$). Men were more likely to be white (80.9% versus 74.0%, $P = .0001$) and affluent. For example, there were more women than men in the lower 2 income quartiles and fewer women in the higher 2 income quartiles. Consistent with their older age at presentation and lower income level, women more often had Medicare and Medicaid insurance. These differences in demographics persisted even after stratifying by type of mitral valve procedure (repair versus replacement). Overall, women had a higher Charlson comorbidity index (1.12 versus 0.94, $P = .0001$) and more often presented on an urgent/emergent basis (36.1% versus 31.6%, $P = .0001$). When the results were stratified by procedure type, these findings were true only for the subset of patients who underwent mitral valve repair. The majority of patients came from an urban location (83.8%), and the 2 groups did not differ with respect to urban versus rural residency.

Operative Data

Mitral valve repair was performed in 46.6% of the patients overall (Table 2). Women underwent repair less often than men (37.9% versus 55.9%, $P < .001$). That was also true when the sex difference in repair versus replacement was examined for each of the 4 years in the study period (Table 3). For the overall population of patients who underwent mitral valve surgery, there was a significant sex difference with respect to undergoing concomitant tricuspid valve surgery and Maze procedure. A greater proportion of women underwent concomitant tricuspid valve repair (9.4% versus 4.4%, $P = .0001$), tricuspid valve replacement (1.5% versus 0.8%, $P = .0001$), and Maze procedure (28.2% versus 24.1%, $P = .0001$). When the results were stratified by type of procedure, women had a consistently higher proportion of concomitant tricuspid valve repair and Maze procedure than men. In contrast, men and women did not differ with respect to concomitant tricuspid valve replacement when the results were stratified by type of mitral valve procedure. In the repair group, women had a higher incidence of pacemaker insertion than men (7.0% versus 5.4%, $P = .0033$), whereas in the replacement group, intra-aortic balloon pump use was higher in men (8.0% versus 6.2%, $P = .0031$).

Hospital Outcomes

Unadjusted hospital outcomes are presented in Table 4. The overall hospital mortality for patients who underwent mitral valve surgery was 3.73%. There was a significant disparity in short-term outcomes with respect to sex. Women were more likely to die (4.16% versus 3.27%, $P = .0058$) and had a longer mean LOS than men (12.5 days versus 10.7 days, $P = .0001$). Because of the skewed distribution of the LOS data, we compared patients by using the median split value to dichotomize the LOS data. Compared with men, women were more likely to experience prolonged hospitalization (LOS ≥8 days; 45.7% versus 60.6%, $P = .0001$). Furthermore, women were less likely to have a favorable disposition, which was defined as discharge to home with or without home health care services (77.5% versus 86.5%, $P = .0001$).

Because men and women differed with respect to the likelihood of undergoing mitral valve repair compared with replacement and because the postoperative outcomes are known to differ by the type of mitral valve surgery, subsequent outcome analyses were stratified by mitral valve procedure (repair versus replacement) (Table 4). As expected, the in-hospital mortality for patients who underwent mitral valve repair (1.68%) was lower than for those who underwent replacement (5.52%). Among the patients who underwent

Table 3. Trends in Mitral Valve Repair over Time, Stratified by Sex

Year	Overall	Men	Women	*P*
2005-2008	46.6%	55.9%	37.9%	<.0001
2005	44.7%	53.0%	36.5%	.0001
2006	43.9%	52.9%	35.7%	.0001
2007	48.9%	58.9%	39.6%	.0001
2008	49.4%	59.0%	39.9%	.0001

Table 4. Unadjusted Hospital Outcomes

	Overall			Mitral Valve Repair			Mitral Valve Replacement		
Hospital Outcomes	Male	Female	*P*	Male	Female	*P*	Male	Female	*P*
LOS, d*	10.7, 7 (5-12)	12.5, 9 (6-15)	.0001	8.1, 6 (4-8)	9.6, 7 (5-11)	.0001	13.9, 9 (6-16)	14.3, 10 (7-17)	.2409
LOS ≥8 d	45.7%	60.6%	.0001	31.9%	45.6%	.0001	63.0%	69.6%	.0001
In-hospital death	3.27%	4.16%	.0058	1.39%	2.06%	.0328	5.65%	5.44%	.7128
Discharge to home	86.5%	77.5%	.0001	91.2%	82.2%	.0001	80.4%	74.5%	.0001

*Data are presented as the mean, median (interquartile range). LOS indicates length of stay.

Table 5. Adjusted Hospital Outcomes Presented as the Odds Ratio (OR) for Women Relative to Men*

	Adjusted for Propensity Scores		Adjusted for Propensity Scores and Concomitant Procedures	
Hospital Outcomes	OR (95% CI)	*P*	OR (95% CI)	*P*
After mitral valve repair				
LOS ≥8 d	1.37 (1.21-1.55)	.0001	1.31 (1.15-1.48)	.0001
In-hospital death	1.27 (0.83-1.94)	.2644	1.16 (0.77-1.76)	.4793
Discharge to home	0.64 (0.54-0.77)	.0001	0.66 (0.55-0.79)	.0001
After mitral valve replacement				
LOS ≥8 d	1.20 (1.07-1.34)	.0021	1.18 (1.06-1.32)	.0039
In-hospital death	0.76 (0.60-0.96)	.0236	0.77 (0.61-0.98)	.0367
Discharge to home	0.83 (0.72-0.96)	.0105	0.83 (0.72-0.96)	.0099

*CI indicates confidence interval; LOS, length of stay.

mitral valve repair, women had a higher hospital mortality (2.06% versus 1.36%, *P* = .0328), had a higher mean LOS (9.6 days versus 8.1 days, *P* = .0001), and were less likely to be discharged home (82.2% versus 91.2%, *P* = .0001) than men. The sexes were significantly different with respect to LOS times ≥8 days for both the repair and replacement groups. Furthermore, in parallel with the overall findings, women in the replacement group were also less likely than men to be discharged to home (74.5% versus 80.4%, *P* = .0001). In contrast, among the subset of patients who underwent mitral valve replacement, there was no difference between men and women with respect to hospital mortality.

Propensity Score–Adjusted Comparisons

Propensity scores were generated to balance men and women with respect to the following baseline characteristics: age, urban residency, Medicare and Medicaid status, income quartile, admission status, and the Charlson comorbidity index. Logistic regression was performed to assess the impact of adjusting for this mix of covariates. When we examined the likelihood of replacement, women were still more likely to undergo mitral valve replacement than men, even after adjustment for propensity scores (odds ratio, 1.78; 95% confidence interval, 1.64-1.93; *P* = .0001). We examined hospital outcomes stratified by mitral valve procedure (repair versus replacement) after adjustment for propensity scores and concomitant procedures (tricuspid valve repair, tricuspid valve replacement, and Maze) (Table 5). After adjustment, women who underwent mitral valve repair were no longer at a higher risk for in-hospital mortality. Interestingly, although unadjusted comparisons did not reveal a difference between the sexes with respect to the in-hospital mortality of patients who underwent mitral valve replacement, hospital mortality was lower for women than for men after adjusting for propensity score and concomitant procedures. After adjusting for propensity score and concomitant procedures, the disparity with respect to prolonged hospitalization (LOS ≥8 days) and disposition status persisted for both the repair and the replacement subsets.

DISCUSSION

We undertook this investigation to assess whether male and female patients present for mitral valve surgery with different baseline characteristics and whether sex may influence the type of procedure used and hospital outcomes. Significant differences in baseline characteristics exist between men and women who present for mitral valve surgery. Women tended to be older, be less affluent, and have more comorbidities; they more often presented on an urgent/emergent basis. Others have reported similar findings for patients undergoing aortic valve surgery [Duncan 2006]. At presentation, women were older and had more comorbidities (including hypertension, heart failure, pulmonary hypertension, and diabetes) compared with men [Duncan 2006]. Others have found that women more often present emergently for combined CABG/valve surgery [Ibrahim 2003; Doenst 2006]. The Charlson comorbidity index was used to avoid the limitation of missing

comorbidity data. This index has been validated for use with large administrative databases and includes data on hypertension, congestive heart failure, diabetes mellitus, renal insufficiency, and other comorbidities [Deyo 1992].

The sex disparity in clinical presentation that we and others have documented identifies an important area for future improvement in the care of patients with valvular heart disease. The less favorable preoperative profiles of women compared with men may be related to physician referral bias. For example, women with coronary disease are less likely to undergo percutaneous coronary intervention or CABG [Bearden 1994; Weitzman 1997]. Similarly, among patients with severe mitral valve regurgitation, women were less likely than men to be referred for surgery, even after adjusting for age, ejection fraction, and regurgitation severity [Avierinos 2008]. Alternatively, delayed referral for women may be related to their smaller body surface area. For patients with severe mitral valve regurgitation, absolute left ventricular and atrial diameters are smaller in women [Avierinos 2008]. According to the most recent guidelines for the management of patients with valvular heart disease, an indication for surgical intervention is recommended for an absolute left ventricular end-systolic dimension of ≥4.0 cm [Bonow 2008]. If physician-referral practices do not take into account the smaller sizes of women, the severity of mitral valve regurgitation may be underestimated for women. Indeed, after normalization for body surface area, women actually have larger left ventricular and atrial dimensions [Avierinos 2008]. Other issues, such as access to care or a woman's willingness to seek early intervention, may also play a role.

The advantages of mitral valve repair include a lower operative mortality, improved long-term survival, better preservation of both early and late ventricular function, and fewer valve-related complications, such as thromboembolism, endocarditis, anticoagulation-related bleeding events, and late prosthesis dysfunction [Perier 1984; Grossi 1998]. Using data from the largest all-payer database in the United States, we found that women were less likely than men to undergo mitral valve repair (37.9% versus 55.9%, $P = .0001$). Others have reported similar findings. In a recent publication, Gammie et al analyzed data from the Society of Thoracic Surgeons (STS) National Cardiac Database and found that 53.2% of patients who underwent isolated mitral valve repair or replacement were women, with significantly fewer women undergoing repair than replacement (44.3% versus 64.5%, $P < .0001$) [Gammie 2009]. Others have reported that women are less likely than men to receive mitral valve repair at the time of combined CABG and valve surgery [Ibrahim 2003; Doenst 2006]. It is possible that patients with worse preoperative profiles, such as a higher Charlson comorbidity index and a more urgent/emergent presentation, influence surgeon comfort in attempting mitral valve repair to correct the disease pathology. In our analysis, however, the disparity in the selection of mitral valve procedure persisted even after adjustment for propensity scores that accounted for those variables. Therefore, differences in baseline characteristics may not completely explain this discrepancy. Although the propensity scores derived from the database accounted for a variety of clinical variables, including the composite Charlson comorbidity index, they did not account for disease etiology. Consequently, a worse preoperative profile may be a surrogate for a different disease process that may ultimately be less suited for repair. Indeed, women had a higher incidence of a concomitant Maze procedure, as well as tricuspid valve repair and replacement. Atrial fibrillation and secondary tricuspid valve regurgitation are well known sequelae of long-standing mitral valve disease. This higher likelihood of concomitant procedures may reflect a delayed referral, which is consistent with the older age of women at surgical intervention. On the other hand, it is possible that women are less likely to seek medical attention for their symptoms.

Differences in disease biology may account for some of these findings. Ibrahim et al [2003] reported on sex differences with respect to mitral valve disease pathology in patients who underwent combined CABG and valve intervention in Toronto General Hospital. The study included 481 patients who underwent CABG/mitral valve surgery over the previous decade (1990-2000). Compared with men, women more often had mitral stenosis (8.3% versus 2.05%) and rheumatic disease (21% versus 6.9%) [Ibrahim 2003]. Another study from Canada reported similar findings for 863 patients who underwent mitral valve replacement between 1976 and 2006. Mitral stenosis was an indication for surgery in 33% of women, compared with 23% in men [Kulik 2009]. In a large retrospective study from the Mayo Clinic, Avierinos et al [2008] reported findings on patients with a diagnosis of mitral prolapse who underwent an echocardiographic examination between 1989 and 1998. Compared with men, women had more anterior and bileaflet prolapse [Ibrahim 2003]. Consequently, differences in disease biology may play a role in the decision to repair or replace the mitral valve. Our analysis does not provide information on the etiology (degenerative versus rheumatic) and type of mitral valve disease (stenosis versus regurgitation) because we believe that the diagnostic coding for these entities needs to be validated for accuracy before this information can be used for clinical comparisons. Therefore, other database sources with more rigorous clinical detail, such as the STS National Cardiac Database, may be better suited for examining this issue.

Our unadjusted comparisons revealed that women had a higher overall in-hospital mortality. This difference appeared to be driven mainly by the higher mortality for women compared with men in the repair subset. Furthermore, following adjustment for propensity scores and concomitant procedures, this difference was no longer statistically significant. Identifying the factors responsible for the less favorable preoperative profiles for women presenting for mitral valve repair may positively affect their hospital outcomes.

Our results are consistent with those of others. Song et al [2008] reported that of the patients who underwent isolated mitral valve repair or replacement, women had a higher hospital mortality than men (3.9% versus 2.4%). Risk adjustment showed that this difference in mortality appeared to be driven primarily by the higher mortality for women in their 40s (approximately 2.5 times that of men) and 50s (2 times that of men), whereas this disparity appeared to even out at older

ages. The authors postulated that changes in ovarian function might be at least partly responsible for these findings. Ibrahim et al also reported a higher hospital mortality for women, both for isolated mitral valve surgery and for combined CABG/mitral valve intervention [Ibrahim 2003]. Doenst et al reported a higher perioperative mortality for women who underwent combined CABG/valve surgery [Doenst 2006]. The NIS database contains data only on the initial hospitalization, and therefore follow-up information is not available. Others have reported similar long-term survival rates with respect to sex for isolated mitral valve replacement and combined CABG/valve interventions [Doenst 2006; Kulik 2009].

Compared with men, women had a longer LOS and were less likely to be discharged to home. This finding was true for patients who underwent repair and for those who underwent replacement, even after adjustment for propensity scores and concomitant procedures. The longer hospital LOS for women compared with men may be related to several factors. Because this difference persisted even after adjustment for baseline characteristics, it appears less likely to be related to differences in preoperative profiles. Although hard clinical end points, such as the ones included in our analysis, are difficult to miscode, the limitations of the NIS database did not allow us to reliably compare the incidences of various postoperative complications of men and women. Data from the STS National Cardiac Database, however, have shown similar postoperative complications with respect to sex—including stroke, renal failure, prolonged ventilation, and atrial fibrillation—for patients who have undergone isolated mitral valve repair or replacement. In addition, the sexes were similar with respect to postoperative complications, such as myocardial infarction, stroke, and renal failure, for patients who underwent combined CABG and valve surgery [Ibrahim 2003]. Whether sex-related differences exist with respect to the return to baseline physical status is unknown. Alternatively, socioeconomic factors may play a role. Because women have a higher longevity on average, they may be more likely to be living alone, which may influence a physician's decision regarding discharge location.

Our reported overall rate of mitral valve repair of 46.6% over a 4-year period (2005-2008) is lower than the repair rate of 56% reported by Gammie et al [2009], who used data from the STS database over an 8-year period (2000-2007). Several differences between the 2 databases in data capture may explain this discrepancy. The NIS database is a stratified sample of approximately 20% of hospital admissions in the United States, and data are subsequently weighted to give an adequate representation of national trends. In contrast, participation in the STS database remains voluntary. Furthermore, participating practices in the STS database may differ significantly from nonparticipating practices [Taylor 2005]. The NIS database has been suggested to be better for evaluating trends, because increased participation in the STS database over time may skew reported trends [Barnett 2009]. These factors should be carefully considered, and comparisons of data from different database sources should be interpreted with caution.

Limitations

The NIS is a stratified probability sample of state inpatient databases that includes data on approximately 20% of hospital admissions in the United States. Although we weighted the data to make them more applicable to the entire inpatient population, the possibility of sampling bias exists. The purpose of administrative databases is to gather data for billing purposes and can be limited by erroneous coding; however, the HCUP quality-control measures [AHRQ 2010] and our strict inclusion and exclusion criteria should minimize these possibilities. In addition, the hard clinical end points used in our analysis are difficult to miscode. The inadequate representation of several variables of interest in the NIS database, however, limited our ability to use that information for clinical comparisons. For example, the diagnostic coding for degenerative versus rheumatic valve disease and the type of mitral valve disease (stenosis versus regurgitation) in the NIS database needs to be validated for accuracy before this information can be used for clinical comparisons. These unaccounted-for factors may have influenced surgeon decision to perform mitral valve repair versus replacement. The limitations of the NIS database did not allow us to reliably compare the incidences of various postoperative complications with respect to sex. We compared patient preoperative risk profiles by using the Charlson comorbidity index, which has been validated for use with large administrative databases [D'Hoore 1996]. Specific information on New York Heart Association (NYHA) class was not available, however. The NYHA class is an important predictor of postoperative outcomes in patients undergoing mitral valve surgery [Tribouilloy 1999]. Data from the NIS database did not allow us to stratify patients according to NYHA class. The NIS database contains only data on the initial hospitalization; therefore, follow-up information is not available.

Several advantages of the NIS database make it particularly well suited to study national trends, and it offers additional strengths over existing databases, most notably the STS National Cardiac Database. The NIS uses different sources and methods to acquire data, participation is not voluntary, and sampling is weighted to reflect national averages. Increased participation in the STS database over time may skew reported trends [Barnett 2009]. Furthermore, participating practices in the STS database may differ significantly from nonparticipating practices [Taylor 2005]. NIS is the largest all-payer database in the United States, and some of its limitations are offset by large patient volumes, hard clinical end points, and the opportunity to explore real-world community data—making our findings widely applicable across hospitals in the United States.

In conclusion, women present for mitral valve surgery with worse preoperative profiles. After adjustment for propensity scores, women had a longer LOS, had a less favorable disposition status, and, most importantly, were less likely than men to undergo mitral valve repair. The unadjusted in-hospital mortality rate was higher for women, and this difference appeared to be mainly driven by the higher mortality for women in the repair subset, compared with men. After adjustment for propensity scores and concomitant procedures, this

difference was no longer statistically significant. Nevertheless, this sex disparity reflects the current reality in surgical practice and identifies an important area for future improvement in the care of patients with valvular heart disease. Earlier referral for surgical intervention has been endorsed by the most recent American College of Cardiology/American Heart Association guidelines for the management of patients with valvular heart disease [Bonow 2008]. Avoiding delays in referral for surgical intervention and medical optimization of comorbid conditions may improve the sex gap in the outcomes of patients who undergo mitral valve surgery.

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