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Research paper

Impact of sex on long-term outcomes following mitral valve repair

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ABSTRACT

Introduction: Previous studies have identified inferior outcomes for women undergoing mitral valve (MV) surgery compared to men, although the cause of this discrepancy has not been identified. We look to isolate surgical approach to identify any impact that sex has on outcomes in order to better inform clinical decision making.
Materials and methods: In this propensity matched, retrospective, single-center study, outcomes were compared between males and females undergoing a MV repair between 2004 and 2018. The primary outcome was defined as mortality at any point in the follow-up period. Secondary outcomes included stroke, myocardial infarction (MI), repeat revascularization, complications arising from the initial procedure, and postoperative cardiac remodeling.
Results: A total of 188 males and 188 females were included after propensity matching. At a median follow up time of 7.6 years, there were 25 deaths in the male group (26.8%) and 23 in the female group (28.2%) ($p = 0.771$). There were no significant differences in MI, stroke, post-operative pacemaker insertion, or rehospitalization following MV repair. Left ventricular (LV) size for males was reduced from an initial 55.6 ± 7.3 mm to 49.9 ± 7.4 mm ($p < 0.001$), and for females from an initial 51.5 ± 7 mm to 46.9 ± 7.1 mm ($p < 0.001$). LV ejection fraction (LVEF) was reduced with a preoperative LVEF for males of 57.7% ± 8.9% and 53.7% ± 9.6% postoperatively ($p = 0.002$), and LVEF for females of 57.8% ± 9.1% preoperatively and 54.8% ± 9.2% postoperatively ($p < 0.001$). Left atrial (LA) volume was reduced from an initial 51 ± 22 ml/m^2 to 43.7 ± 25.2 ml/m^2 ($p < 0.001$), and 50.9 ± 19.2 ml/m^2 to 44.2 ± 19.8 ml/m^2 ($p < 0.001$), for males and females respectively. LA diameter was reduced for males from an initial 49.7 ± 9.7 mm to 47.3 ± 9.4 mm ($p = 0.043$), and from 48 ± 8.7 mm to 44.3 ± 9.1 mm for females postoperatively ($p = 0.017$).
Conclusions: Current literature demonstrates inferior outcomes for females when compared to males undergoing MV surgery with patients undergoing a variety of surgical approaches. The results of this study suggest that surgical intervention for a subset of patients, those undergoing repair of the MV, is safe and offers similar outcomes for males and females.

1. Introduction

Valvular heart disease (VHD) has an estimated 2.5% prevalence in developed nations and is estimated to be up to 13.3% in those over 75 years of age [1]; with aortic valve disease and mitral valve disease (MVD) comprising the majority of VHD [1]. Currently, no medical therapies are available to treat MVD and surgical repair or replacement of the diseased valve is the only definitive treatment. Since MVD has many potential etiologies, is commonly associated with multiple comorbidities, and a variety of surgical approaches exist ranging from repair of an isolated leaflet to complete replacement with a prosthetic valve, surgical intervention is considered based on a variety of factors and expected outcomes. Several parameters have been evaluated for their predictive value regarding long-term outcomes of MV repair including age, BMI, diabetes, left ventricular ejection fraction (LVEF), etiology of valvular disease, surgical approach, aortic clamping time, coronary artery disease, and renal impairment [2–4]. Previous studies have established that males and females often respond differently to comparable treatments for a variety of conditions, in MV disease sex is regularly disregarded in clinical practice with males and females receiving treatment based on the same guidelines [5–7].

By approaching MVD in males and females using a single set of guidelines without considering sex, one group of patients may be receiving sub-optimal treatment. Previous studies have found that while mitral regurgitation (MR) is just as common in women as in men, they are less likely to receive surgery [1,8–10]. Women are also referred later in the disease process, with higher rates of comorbidities and their outcomes are generally inferior especially in the 40–59 year old population with up to 2.5× increase in mortality and up to a 10% reduced survival rate after 10 years

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postoperatively for severe MR [6,8–17]. Operative characteristics have also been found to differ between men and women. Several studies have found that valve replacement is more common than repair for women and that women were more likely to undergo concomitant procedures at the time of MV intervention when compared to men [12,14,15].

There is paucity in the literature seeking to identify if variations in surgical intervention between sex for the same disease process impacts postoperative outcomes. Women have historically been underrepresented in clinical trials for novel cardiovascular drugs or surgical interventions [13,18], and the current literature that does target these variations is largely limited to retrospective studies with short follow-up duration or small cohorts. Presently both sexes are treated using identical guidelines and women continue to show poorer postoperative outcomes when compared to men without explanation as to the cause. This discrepancy in outcomes must be identified and accounted for when considering surgical intervention. In this retrospective study, we look to identify variations in postoperative outcomes between males and females who have undergone MV repair surgery to better inform the clinical decision-making process when considering surgical intervention for MVD.

2. Patients and methods

Preoperative and postoperative data were collected from a database that included the type of surgical intervention, preoperative comorbidities, and postoperative complications and outcomes. The patient database included 2912 patients who had undergone either a MV repair or replacement from 2004 to 2018 at the Mazankowski Heart Institute, University of Alberta Hospital. This database also includes follow up information and outcomes from all post-operative assessments performed at the University of Alberta Hospital.

2.1. Data source

The APPROACH (Alberta Provincial Project for Outcome Assessment in Coronary Heart Disease) database, electronic health records, and discharge abstract database to detect events after discharge and at other hospitals were used to obtain all data. The APPROACH database contains detailed clinical information from all patients undergoing coronary angiography in Alberta. Prospective clinical data were collected from all 3 hospital sites with the provision of cardiac catheterization in the province of Alberta since 1995. These patients are followed prospectively for outcomes, including subsequent revascularization and death. The details of this database and its use have been previously described [19]. Details were collected retrospectively for this cohort of patients from the previously mentioned databases. The data collected includes baseline demographics, operative details, postoperative mortality, complications arising from the initial procedure, readmission to hospital, requirement of reintervention, and cardiac remodeling data.

2.2. Study cohort

Included in this study were patients with symptomatic severe MR that met indications for MV repair [5]. These patients underwent repair of the MV at the Mazankowski Heart Institute, University of Alberta Hospital, between January 1, 2004, and December 31, 2018 (Fig. 1). Patients were excluded from this cohort if the patient had endocarditis (n = 20), missing values in pump or cross-clamp time (n = 21) and if the patient was in a critical preoperative state (n = 2) (need for intra-aortic balloon pump, acute renal failure requiring dialysis, or respiratory failure requiring ventilation). Of the 376 remaining patients, 188 males and 188 females were propensity-matched and included in this study (Fig. 1). Outcomes were measured over a maximum 15-year span with a median follow-up duration of 7.6 years.

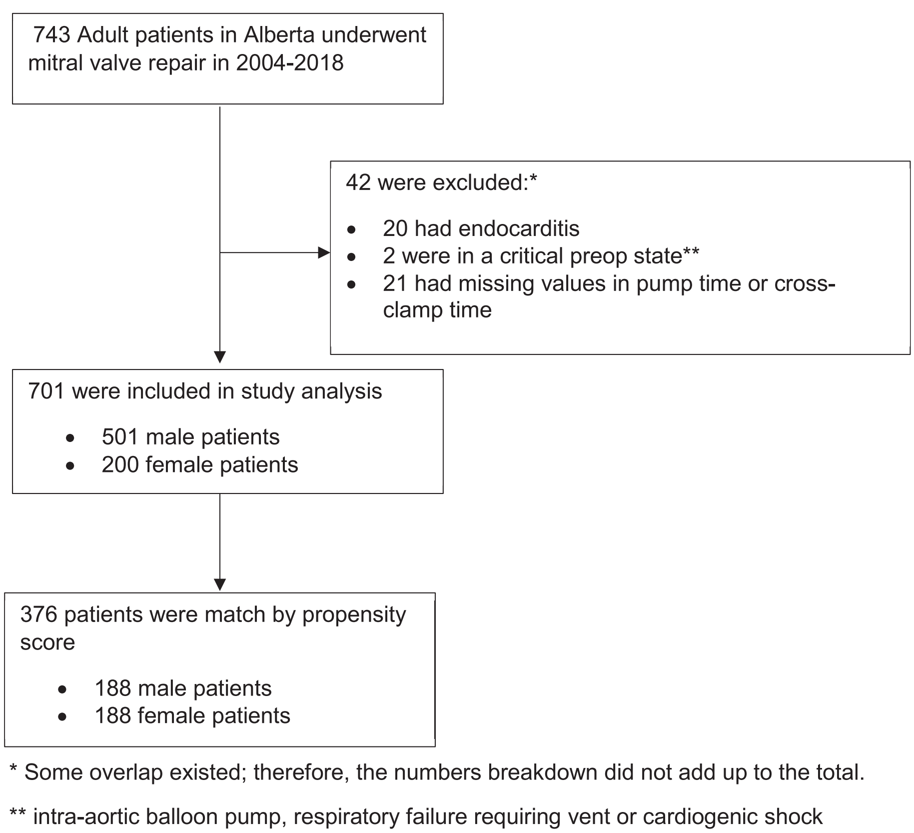

Fig. 1. Study population flowchart. *Some overlap existed; therefore, the numbers breakdown did not add up to the total. **Intra-aortic balloon pump, respiratory failure requiring vent or cardiogenic shock.

2.3. Outcomes

The primary outcome was defined as mortality at any point in the follow-up period. Secondary outcomes included stroke, myocardial infarction (MI), repeat revascularization, complications arising from the initial procedure, sepsis, acute kidney injury (AKI), and new-onset atrial fibrillation (AF). Anatomical, hemodynamic, and functional assessments included preoperative and postoperative left ventricular (LV) internal dimension in diastole (LVIDd), left atrial (LA) volume index (ml/m^2), LA size (mm), LV ejection fraction (EF), MV peak and mean gradients, and MV area (cm^2). Outcome data were collected during the admission for the index procedure and after discharge and were identified based on admitting diagnosis for any readmission. MI was defined as the primary diagnosis of non-ST-segment elevation MI or ST-segment elevation MI for readmission any time after the index procedure. Stroke included both hemorrhagic and ischemic forms being a primary diagnosis at readmission any time after the index procedure or diagnosed during the index hospitalization. Reoperation of the MV was defined as MV surgical repair or replacement, or repair of complications arising from the index procedure at any time after the index procedure. New-onset AF was defined as AF arising after the index procedure, excluding patients with preoperative AF. Residual moderate to severe MR included moderate or severe MR preceding discharge or a MV reoperation after the index procedure.

2.4. Statistical analysis

Continuous variables and categorical variables were summarized as mean ± standard deviation (SD) and count (percent) respectively. The Society of Thoracic Surgery Risk Score (STS score) for each patient was calculated using the online STS calculator [20]. Propensity score matching techniques were implemented to control for the difference in the baseline covariates. The propensity score was estimated using a multivariable logistic-regression model with biological sex as the dependent variable and the baseline characteristics as covariates including age, BMI, pulmonary disease, cerebrovascular disease, renal disease, current smoker, past smoker, hypertension, dyslipidemia, liver disease, gastrointestinal disease, malignancy, peripheral vascular disease, diabetes mellitus, congestive heart failure, prior MI, prior percutaneous coronary intervention (PCI), prior coronary artery bypass grafting (CABG), prior atrial fibrillation/flutter, pump time, cross-clamp time, STS score and left ventricular ejection fraction. Greedy matching techniques without replacement and a caliper width equal to 0.2 of the standard deviation of the logit of the propensity score were applied to match male patients 1:1 to female patients. Standardized mean difference was used to evaluate the balance before and after matching. A standardized difference of 0.1 or less was considered as the ideal balance.

The paired *t*-test was used to compare the pre- and post-operative echocardiographic measurements. The absolute changes in LV size, LA size, and LA volume index between male and female patients were compared with the linear mixed model which was indexed by Body Surface Area. Cox proportional hazards regression models and the Fine & Gray model [21] were implemented to determine the hazard ratios of sex difference on the primary and non-fatal secondary outcomes. The postoperative complications by sex were compared with the McNemar test. The survival curve was plotted for all-cause mortality at longest follow-up using Kaplan-Meier methods. Reverse Kaplan-Meier methods were used to estimate the median follow-up time. Statistical analyses were executed using the SAS 9.4 (SAS Institute, Cary NC) A p-value < 0.05 was deemed of statistical significance. All statistical tests were two-sided.

3. Results

3.1. Baseline demographics

The study included 2912 consecutive patients who had undergone MV surgery at the University of Alberta between January 1, 2004, and December 31, 2018 (Fig. 1). Of these patients, 743 underwent repair of the MV. Baseline demographic data are summarized in Table 1. Preoperatively and prior to propensity matching, males were more likely to have pulmonary disease, renal disease, and were more likely to have a history of smoking (Table 1). After propensity matching these differences were not present (Table 2).

Table 1
Baseline characteristics prior to propensity matching of patients underwent mitral valve repair (N = 701).

Characteristics	Male (N = 501)	Female (N = 200)	SMD
Age, years	63.2 ± 12.9	63.4 ± 14.5	0.01
BMI, kg/m^2	27.2 ± 4.6	26.6 ± 5.3	0.13
Pulmonary disease	170 (33.9%)	47 (23.5%)	0.23
Cerebrovascular disease	29 (5.8%)	11 (5.5%)	0.01
Renal disease	32 (6.4%)	3 (1.5%)	0.25
Current smoker	71 (14.2%)	21 (10.5%)	0.11
Past smoker	227 (45.3%)	57 (28.5%)	0.35
Hypertension	311 (62.1%)	113 (56.5%)	0.11
Dyslipidemia	336 (67.1%)	124 (62%)	0.11
Liver disease	6 (1.2%)	1 (0.5%)	0.08
Gastrointestinal disease	64 (12.8%)	28 (14%)	0.04
Malignancy	19 (3.8%)	6 (3%)	0.04
Peripheral vascular disease	11 (2.2%)	2 (1%)	0.1
Diabetes	43 (8.6%)	16 (8%)	0.02
Heart failure	134 (26.7%)	54 (27%)	0.01
Prior history of MI	25 (5%)	6 (3%)	0.1
Prior history of PCI	5 (1%)	0 (0%)	0.14
Prior history of CABG	14 (2.8%)	6 (3%)	0.01
Atrial fibrillation/flutter	42 (8.4%)	14 (7%)	0.05
Pump time, min	150 ± 46	129.4 ± 36.6	0.5
X-clamp time, min	118 ± 35.7	102.5 ± 30.5	0.47
STS score	0.9 ± 0.7	1.1 ± 1	0.2
Ejection fraction, %			
≥50%	353 (70.5%)	143 (71.5%)	0.02
40% ≤ EF < 50%	32 (6.4%)	5 (2.5%)	0.19
30% ≤ EF < 40%	16 (3.2%)	7 (3.5%)	0.02
<30%	8 (1.6%)	1 (0.5%)	0.11
Missing	92 (18.3%)	44 (22%)	0.09
Repair type			
Anterior resection	10 (2%)	4 (2%)	0
Posterior resection	206 (41.3%)	78 (39%)	0.05
Anterior neochord implantation	142 (28.3%)	48 (24%)	0.1
Posterior neochord implantation	198 (39.5%)	65 (32.5%)	0.15
Annuloplasty ring	489 (97.6%)	190 (95%)	0.14
Ring size (mm)	29.1 ± 2.1	29.1 ± 2.5	0.01

Values are no. (%) or mean ± SD.

3.2. Surgical detail

Intraoperatively males experienced longer time spent on cardiopulmonary bypass and with a cross-clamp placed when compared to females. There was no significant difference between the rates of annuloplasty ring use, rates of leaflet resection, or neochord implantation (Table 1).

3.3. Primary outcomes and post-MVr survival

The primary and secondary outcomes are summarized in Tables 3 & 4. At a median follow up time of 7.6 years, there were 48 deaths in our study population with 25 in the male group (26.8%) and 23 in the female group (28.2%) [HR: 1.09; 95% CI: 0.62–1.92; p = 0.771]. There was no significant difference in mortality between females and males at any point in the follow-up period (Table 3, Fig. 2).

3.4. Secondary outcomes

Postoperative valvular leak ranged from mild to severe in this study population with 3 males (2.8%) and 8 females (7.7%) experiencing moderate-severe MR at a median follow up time of 4 months [HR: 0.38; 95% CI: 0.10–1.43; p = 0.153]. MI was recorded in 7 males (7.6%) and 4 females (6.8%) [HR: 1.73; 95% CI: 0.51–1.90; p = 0.379]. Postoperative stroke was recorded for 10 males (10.0%) and 12 females (11.1%) [HR: 0.84; 95% CI: 0.37–1.95; p = 0.693]. The number of patients rehospitalized at longest follow up was 88 (61.3%) males and 101 females (62.9%) [HR:

Table 2
Baseline characteristics after propensity matching of patients underwent mitral valve repair (N = 376).

Characteristics	Male (N = 188)	Female (N = 188)	SMD
Age, years	61.9 ± 14.8	62.5 ± 14.5	0.04
BMI, kg/m^2	26.8 ± 5	26.6 ± 5.2	0.04
Pulmonary disease	46 (24.5%)	45 (23.9%)	0.01
Cerebrovascular disease	9 (4.8%)	10 (5.3%)	0.02
Renal disease	3 (1.6%)	3 (1.6%)	0
Current smoker	26 (13.8%)	21 (11.2%)	0.08
Past smoker	61 (32.4%)	54 (28.7%)	0.08
Hypertension	103 (54.8%)	103 (54.8%)	0
Dyslipidemia	119 (63.3%)	116 (61.7%)	0.03
Liver disease	0 (0%)	1 (0.5%)	0.06
Gastrointestinal disease	27 (14.4%)	24 (12.8%)	0.05
Malignancy	5 (2.7%)	5 (2.7%)	0
Peripheral vascular disease	0 (0%)	2 (1.1%)	0.08
Diabetes	15 (8%)	14 (7.4%)	0.02
Heart failure	46 (24.5%)	49 (26.1%)	0.04
Prior history of MI	6 (3.2%)	6 (3.2%)	0
Prior history of PCI	0 (0.0%)	0 (0.0%)	0
Prior history of CABG	6 (3.2%)	5 (2.7%)	0.03
Atrial fibrillation/flutter	9 (4.8%)	12 (6.4%)	0.07
Pump time, min	130.7 ± 37.4	129.9 ± 36.9	0.02
X-clamp time, min	104 ± 31	103.1 ± 30.5	0.03
STS score	0.9 ± 0.8	0.9 ± 0.7	0.01
Ejection fraction, %			
≥50%	134 (71.3%)	135 (71.8%)	0.01
40% ≤ EF < 50%	6 (3.2%)	5 (2.7%)	0.03
30% ≤ EF < 40%	8 (4.2%)	6 (3.2%)	0.06
<30%	0 (0%)	1 (0.5%)	0.05
Missing	40 (21.3%)	41 (21.8%)	0.01

Values are no. (%) or mean ± SD.

0.82; 95% CI: 0.61–1.08; p = 0.161]. Reoperation of the MV was required in 5 males (5.7%) and 5 females (2.9%) [HR: 0.99; 95% CI: 0.29–3.38; p = 0.986]. Postoperatively pacemakers were inserted in 4 males and 2 females (p = 0.414). 7 males and 7 females experienced AKI post MV repair (p = 1.000). New onset AF was recorded for 57 males (30.3%) and 53 females (28.2%) (p = 0.637). 2 males (1.1%) and 2 females (1.1%) experienced sepsis postoperatively (p = 1.000) (Tables 3 & 4).

3.5. Cardiac remodeling

Postoperative cardiac remodeling data are summarized in Tables 5 & 6. Both males and females showed significant cardiac chamber remodeling post-MV repair. Both groups demonstrated a significant reduction in LV size. Male LV size was initially on 55.6 ± 7.3 mm and was reduced to 49.9 ± 7.4 mm postoperatively (p < 0.001). Females began with an LV size of 51.5 ± 7 mm preoperatively to 46.9 ± 7.1 mm postoperatively (p < 0.001). Males also showed a significant reduction in LVEF with a preoperative LVEF of 57.7% ± 8.9% for males and a postoperative LVEF of 53.7% ± 9.6% (p = 0.002). Females began with a LVEF of 57.8% ± 9.1% and postoperative LVEF was 54.8% ± 9.2% (p < 0.001). Males also showed a reduced LA volume with an average size of 51 ± 22 ml/m^2 preoperatively and 43.7 ± 25.2 ml/m^2 postoperatively (p < 0.001), females initially had a LA volume of 50.9 ± 19.2 ml/m^2 preoperatively and 44.2 ± 19.8 ml/m^2 postoperatively (p < 0.001). Both males and females demonstrated a significant reduction in LA diameter. Males began with an average LA diameter of 49.7 ± 9.7 mm and a postoperative LA diameter of 47.3 ± 9.4 mm (p = 0.043). Female LA diameter decreased from 48 ± 8.7 mm preoperatively to 44.3 ± 9.1 mm postoperatively (p = 0.017). There were no significant changes in MV peak or mean gradients, MV area, or absolute changes to LV size, LA size, or LA volume index when these values were indexed by body surface area (Tables 5 & 6).

Table 4
Post-operative complications post MV repair.

Outcome	Male (N = 188)	Female (N = 188)	p value
New AF	57 (30.3%)	53 (28.2%)	0.637
Pacemaker insertion	4 (2.1%)	2 (1.1%)	0.414
Sepsis	2 (1.1%)	2 (1.1%)	1.000
Acute Kidney injury	7 (3.7)	7 (3.7)	1.000

4. Discussion

Although previous data have demonstrated inequality in postoperative outcomes between males and females undergoing MV surgery [6,8–17], there is paucity in the literature regarding the factors contributing to this disparity. By isolating for surgical repair and comparing differences in outcomes based on sex alone, we attempt to address this gap in knowledge thereby striving to better inform the clinical decision-making process when considering intervention for MVD. First and foremost, there are relatively similar outcomes following MV repair between males and females. That is, there are no significant differences in morbidity or mortality. Both pre- and intraoperatively females exhibited favorable characteristics as compared to male counterparts. Females presented with lower rates of pulmonary disease, renal disease, prior smoking, shorter times spent on cardiopulmonary bypass, and less time with a cross-clamp placed intraoperatively. Furthermore, cardiac remodeling did not differ between the sexes. This is in contrast to recent findings from our group demonstrating significant differences in cardiac remodeling post MV replacement [22].

Differences in preoperative presentation and postoperative outcomes between males and females undergoing MV surgery have been a key finding in several preceding studies [6,8–17,22]. In a study comprised of over 45,000 patients undergoing MV surgery, McNeely and Vassileva highlighted increased rates of preoperative comorbidities and increased complex MV disease presentation for females as compared to males [8]. Furthermore, they identified significantly worse postoperative outcomes for females, including increased rates of mortality and postoperative morbidity. After adjustment for baseline risk factors, morbidity and mortality rates were similar between the groups, although females still had increased rates of in-hospital mortality post MV replacement. Similar results were

Table 3
Primary and secondary outcomes post MV repair.

Outcomes	Median follow up time	Male (N = 188)[a]	Female (N = 188)[a]	HR (95% CI)	p value
Primary outcome					
Death at 30 days	30 days	2 (1%)	2 (1%)	1.00 (0.14–7.08)	0.998
Death at 1 year	1 year	4 (2.1%)	3 (1.6%)	1.33 (0.30–5.95)	0.707
Death at longest follow up	7.6 years	25 (26.8%)	23 (28.2%)	1.09 (0.62–1.92)	0.771
Secondary outcomes					
Readmission for HF at longest follow up	7.7 years	27 (18.8%)	32 (30.3%)	0.86 (0.52–1.44)	0.563
Readmission for Stroke at longest follow up	8 years	10 (10%)	12 (11.1%)	0.84 (0.37–1.95)	0.693
Readmission for MI at longest follow up	7.9 years	7 (7.6%)	4 (6.8%)	1.73 (0.51–5.90)	0.379
Rehospitalization at longest follow up	7.5 years	88 (61.3%)	101 (62.9%)	0.82 (0.61–1.08)	0.161
Reoperation of MV at longest follow up	8 years	5 (5.7%)	5 (2.9%)	0.99 (0.29–3.38)	0.986
Residual moderate - severe MR at 1 year	4 months	3 (2.8%)	8 (7.7%)	0.38 (0.10–1.43)	0.153

[a] The rates in brackets are estimates from Kaplan-Meier Curve.

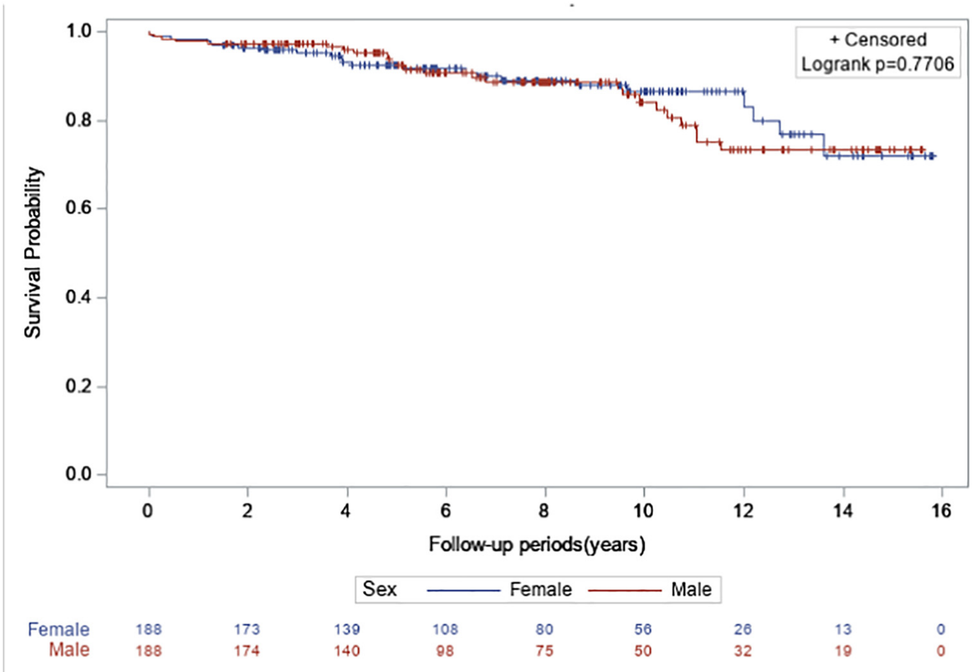

Fig. 2. Kaplan Meier curve for all-cause mortality at longest available follow-up.

demonstrated by Gammie et al. in a study involving 58,000 patients undergoing MV surgery [9]. Proposed causative factors of the aforementioned discrepancies in preoperative presentation and postoperative outcomes between males and females include disease progression, preoperative presentation, comorbidities, and surgical approach. Although comprehensive, the above studies are limited in their ability to identify which factors contribute to this variation in outcomes as numerous variables are present. Additionally, a previous study from our group comparing the outcomes of 622 propensity-matched patients undergoing MV replacement demonstrated similar morbidity and mortality outcomes but significantly different cardiac remodeling results [22]. Our results demonstrated significant remodeling of the LV in males but not in females, and significant remodeling of the LA in females but not in males. Taken together, the results of these studies demonstrated similar results between males and females undergoing MV surgery, but that a difference still exists. When undergoing repair of the MV the heart reacts similarly between the sexes, but when the MV is replaced the remodeling is significantly different. Further research is required in order to elucidate the mechanism of this difference. This difference further illustrates the importance of individualized medicine and the impact sex can have on outcomes after surgery. Care should also be taken with the development of minimally invasive transcatheter MV repair. Several devices are in development and variable phases of clinical trials [23]. During the initial stages of development and testing of these and other mitral valve devices in the future, equal representation between the sexes should be included in order to prevent this same discrepancy in outcomes between the sexes from continuing into a new generation of surgical approaches.

The results we present are less decisive than that of McNeely and Vassileva or Gammie et al. Preoperatively, aside from females being less likely to be prior smokers, all other relevant risk factors, including STS risk score and MVD type, were similar between groups. Furthermore, females and males had similar primary and secondary outcomes postoperatively. Cardiac remodeling was also similar between the groups. Although our results contrast those of previous studies, differences in our approach may help explain this discrepancy. Previous studies have examined the impact of sex on MV surgery in general, treating all the surgical approaches as a single entity. This approach brings forth the possibility of overlooking specific factors that are key contributors to the variation in outcomes, consequently leading to a subset of patients being overlooked by research and receiving sub-optimal clinical care. In this study, we investigated outcomes isolating surgery type in order to remove as many variables as possible. This

Table 5
Hemodynamic, functional, and anatomical changes before and after surgery for MV repair (N = 376).

	Preoperative	Postoperative	p value
LV size LVIDd (mm)			
Male	55.6 ± 7.3	49.9 ± 7.4	< 0.001
Female	51.5 ± 7	46.9 ± 7.1	< 0.001
LV EF (%)			
Male	57.7 ± 8.9	53.7 ± 9.6	0.002
Female	57.8 ± 9.1	54.8 ± 9.2	< 0.001
LA volume index (ml/m^2)			
Male	51 ± 22	43.7 ± 25.2	< 0.001
Female	50.9 ± 19.2	44.2 ± 19.8	< 0.001
LA size (mm)			
Male	49.7 ± 9.7	47.3 ± 9.4	0.043
Female	48.0 ± 8.7	44.3 ± 9.1	0.017
MV peak gradient (mm Hg)			
Male	10.7 ± 7.3	9.8 ± 4.1	0.123
Female	14.7 ± 17.1	10.5 ± 4.6	0.292
MV mean gradient (mm Hg)			
Male	4.8 ± 7	4 ± 2.3	0.532
Female	5.8 ± 10.9	4.3 ± 2.6	0.381
MVA (cm^2)			
Male	2.4 ± 1.1	2.1 ± 0.7	0.869
Female	2.8 ± 2.5	1.9 ± 0.6	0.212

Table 6
Absolute anatomical changes before and after surgery for MV repair (n = 376).

	Male	Female	p value[a]
Absolute changes in LV size (mm)	6.2 ± 5.0	6.3 ± 4.7	0.721
Absolute changes in LA size (mm)	7.5 ± 6.3	7.2 ± 6.9	0.814
Absolute changes in LA volume index (ml/m^2)	17.9 ± 15.6	18.2 ± 15.9	0.366

[a] Indexed by body surface area.

provides the ability to better inform the clinical decision-making process when considering intervention for MVD by establishing optimal sex-specific approaches to MV surgery. Although preceding studies have demonstrated inferior outcomes for females as compared to males undergoing MV surgery, their ability to identify which risk or surgical factors contribute to this inequality is limited as multiple variables are present. Our results suggest that when considering a repair of the MV, postoperative outcomes are similar between the sexes. Therefore, our results indicate that for both females and males presenting MVD, repair of the MV is safe and should be considered equally. Further study is indeed required in order to elucidate the relationship between sex and outcomes after MV surgery. Larger prospective or randomized control trials applying the principles outlined in our paper and differentiating between primary and secondary MR should be conducted allowing for an improved understanding of this relationship. Prospective or randomized control trials would address the limitations of our retrospective, single-center study, providing further evidence regarding the optimal approach to MV surgery in the sexes.

4.1. Limitations

There are limitations to the manuscript we have produced. First, this is a retrospective, single-center study. Inherent in this study type is the inability to randomize patients to the treatment groups and to control for other variables. This includes limited information resulting in the inability to differentiate between MR pathophysiology. We, therefore, included all patients who had received MV repair and attempted to address this limitation by propensity matching patients in order to reduce variability between groups as much as is possible with this study type. Second, after propensity matching 188 males and 188 females were included in our study. These are relatively small groups and it is difficult to make inferences regarding the general population based on this dataset.

5. Conclusions

Current literature demonstrates inferior postoperative outcomes for females as compared to males undergoing MV surgery. However, these studies are limited in their ability to identify the factors contributing to this discrepancy as their study cohorts have largely consisted of patients undergoing a variety of surgical approaches. By separating the patient population based on surgery type, our approach removes additional variables helping to address a gap in knowledge and better inform clinical decision-making for MV surgical intervention. This study provides data suggesting that in a specific subset of MV surgery, MV repair, males and females have similar postoperative outcomes. Surgical intervention for patients undergoing repair of the MV is safe and offers similar outcomes for males and females.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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