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Original Article

Impact of gender on postoperative outcome after posterior chordal preservation during isolated mitral valve replacement: A retrospective propensity score matched study

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Abstract

Background: Female patients experience poorer clinical results after mitral valve surgery. Preserving the sub-valvular chordae may lead to lower morbidity and mortality after mitral valve replacement (MVR) for both genders. This study aimed to compare operative mortality and postoperative morbidity following preservation of posterior mitral leaflet during isolated mechanical MVR, between male and female patients.

Methods: This retrospective study involved adult patients of either gender who had primary isolated MVR. The primary end-point of outcome was a combination of negative postoperative results, including operative mortality and complications. The outcomes were compared based on gender before and after adjusting for preoperative factors related to gender using 1:1 propensity score matching.

Results: The initial sample consisted of 380 patients, mostly female (215/380; 56.57%) with an average age of 51.45±10.79 years. Female patients showed higher rates of previous congestive heart failure, NYHA class III/IV, low ejection fraction, pulmonary hypertension, and atrial fibrillation. After surgery, female patients experienced a significant increase in hospital stay (9.30±3.55 vs 8.95±3.27 days, P = 0.02), total postoperative complications (7% vs 2.4%, P = 0.04), and adverse outcome rates (7.9% vs 2.4%, P = 0.02), with no significant difference in hospital mortality (1.4% vs 0.6%, P = 0.63). In the matched group of 330 patients, there were no significant differences in postoperative results (P < 0.05). Female gender associated with significantly higher odds for the composite of adverse outcomes (OR: 3.45, 95%CI: 1.14 -10.47, P = 0.02), which was not seen in the matched group (OR: 2.05, 95%CI: 0.60-6.94, P = 0.24).

Conclusion: Female gender did not influence the rate of operative mortality after posterior chordal preservation during MVR, but female patients experienced higher rate of overall postoperative complications and longer duration of hospital stay than male patients. When adjusting for preoperative risk factors, female gender did not impact postoperative outcomes.

KEYWORDS

Mitral valve replacement; Chordal preservation; Gender differences; Rheumatic valve disease

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Introduction

Mitral valve disease is a major health issue, leading to significant morbidity and mortality in both genders. However, women are usually referred for mitral valve surgery later in life and may have more severe disease by the time of surgery. Additionally, they often experience different co-morbidities than male patients which may impact surgical results [1, 2]. Generally, men and women experience similar complications after cardiac surgery, but it seems that gender influences the rate of complications, leading to more severe issues and a greater overall increase in the rates of complications and mortality in women [3].

The impact of gender on outcome after MVR remains unclear. In the studies by Wong et al [1], Bradley et al [4], and Chang et al [5] women had a higher rate of in-hospital mortality. In contrast, Munoz-Rivas et al [6] found that women had lower rates of in-hospital mortality and major adverse events compared to men after MVR while Mascherbauer et al [7] reported similar mortality rates. The variation in gender-related results after MVR across studies can be clarified by differences in the epidemiology and causes of mitral valve disease along with variations in surgical methods and strategies.

Posterior mitral leaflet creates an effective seal when the mitral valve closes and keeping it intact can improve valve performance and reduce the risk of post-operative complications. In literature, a debate exists about the effect of chordal preservation on results after MVR. The majority of the research in the literature favors preserving the subvalvular apparatus during MVR [8, 9], but some researchers did not report notable differences in mortality rates or adverse events based on whether the subvalvular apparatus was preserved or not [10].

Although there is a lack of studies regarding gender-related results of chordal preservation during MVR, maintaining the structure and function of the left ventricle during MVR may have a particular role in female patients to reduce the potentially increased risk of adverse outcomes. To clarify the differences in outcomes after MVR based on gender, it is better to focus on standalone MVR and use propensity matching of patients to reduce preoperative discrepancies that may explain the disparities in outcome [11]. Therefore, this study aimed to compare postoperative results of posterior leaflet preservation during isolated MVR between two clinically matched groups of male and female patients.

Patients and Methods

Study population

This retrospective study included adult patients who had isolated primary mitral valve replacement with posterior leaflet preservation, from January 2017 to January 2023 at our institution. We excluded records of patients with concomitant cardiac surgeries, redo-cardiac surgery, age <18 years, mitral valve repair, mitral valve replacement without posterior leaflet preservation, and invalid data of interest. The protocol of this study was assessed by our institutional ethical committee and had an approval number (1398/2024). The patient's consent was not required for retrospective studies.

Surgical technique:

All patients received the standard technique of mechanical mitral valve replacement while keeping the posterior mitral leaflet intact through a median sternotomy approach and cardiopulmonary bypass with moderate hypothermia. The decision to preserve the posterior leaflet was made based on the surgeon's preference, with efforts to maintain the subvalvular chordopapillary structure whenever possible. Complete excision of the anterior mitral leaflet was performed in all patients with sparing of the posterior leaflet and its subvalvular chordopapillary apparatus. The preservation of the subvalvular chordopapillary structure was not favored if it could disrupt the placement of the correct valve size or influence its function, especially if the leaflet or subvalvular chordopapillary structure was thick, stuck together, or shortened.

Table 1: Comparing preoperative clinical characteristics before matching

Variables	Male (n=165)	Female (n=215)	P-value
Age (years)	51.02±10.16	52.68±11.62	0.16
Obesity (BMI>30 kg/m2)	76(46.1%)	113(52.6%)	0.20
PVD	3(1.8%)	7(3.3%)	0.52
CVD	2(1.2%)	5(2.3%)	0.47
Renal dialysis	1(0.6%)	0(0%)	0.43
Respiratory disease	5(3%)	4(1.9%)	0.51
DM	24(14.5%)	41(19.1%)	0.24
IDDM	1(0.6%)	7(3.3%)	0.08
CHF	4(2.4%)	20(9.3%)	0.006*
NYHA class III/IV	73(44.2%)	120(55.8%)	0.03*
LVEF<50%	13(7.9%)	43(20%)	0.001*
PASP >55mmHg	60(36.4%)	107(49.8%)	0.009*
Preoperative AF	17(10.3%)	43(20%)	0.01*
MV pathology			
Stenosis	45(20.9%)	49(29.7%)	
Regurgitation	130(60.5%)	89(53.9%)	0.14
Mixed	40(18.6%)	27(16.4%)	

*Significant difference. BMI: Body mass index. PVD: Peripheral vascular disease. CVD: Cerebrovascular disease. DM: Diabetes mellitus. IDDM: Insulin-dependent diabetes mellitus. CHF: Congestive heart failure. NYHA: New York Heart Association. LVEF: Left ventricular ejection fraction. PASP: Pulmonary artery systolic pressure.AF: Atrial fibrillation. MV: Mitral valve.

Data collection:

The collected data included baseline demographic and clinical data, patient co-morbidities, mitral valve (MV) pathology, intraoperative data, operative mortality, postoperative complications, and length of hospital stay. The preoperative clinical covariates of interest were age, NYHA class, obesity (Body mass index; BMI >30kg/m2), diabetes mellitus (DM), cardiovascular disease (CVD), peripheral vascular disease (PVD), renal dialysis, renal disease, history of congestive heart failure (CHF), and preoperative atrial fibrillation (AF). The collected echocardiographic covariates included left ventricular ejection fraction (LVEF), pulmonary artery systolic pressure (PASP), and mitral valve (MV) pathology.

Study end-points:

The primary end-points of the study were a combined measure of (death/complications), total rate of postoperative complications, and the rate of operative mortality. The evaluated postoperative complications included re-operation for bleeding, new onset AF, neurological complications, renal complications, pulmonary complications, and sternal wound infection. The secondary end-points of outcome included the duration in the ICU and the total length of hospital stay. Results after surgery were evaluated between male and female patients, before and following adjustments for preoperative risk factors and other health issues for both sexes by using the propensity score matching approach.

Postoperative adverse outcomes were defined based on the definitions of the Society of Thoracic Surgeons [12]. Operative mortality was defined as death occurring in-hospital or within 30 days after surgery. Re-operation for bleeding refers to re-exploration in the ICU or operating room for postoperative mediastinal bleeding. New-onset AF was defined as AF requiring treatment after surgery in patients who did not have AF at the start of surgery. Postoperative neurological complications included stroke, transient ischemic attacks, coma, confusion, or seizures. The criteria for defining renal impairment were an increase of

Table 2: Comparing preoperative clinical characteristics after propensity-score matching

Variables	Male (n=165)	Female (n=165)	P-value
Age (years)	51.02±10.16	51.88±11.41	0.51
Obesity (BMI>30 kg/m2)	76(46.1%)	81(49.1%)	0.58
PVD	3(1.8%)	5(3%)	0.72
CVD	2(1.2%)	5(3%)	0.44
Renal dialysis	1(0.6%)	0(0%)	1
Respiratory disease	5(3%)	3(1.8%)	0.72
DM	24(14.5%)	24(14.5%)	1
IDDM	1(0.6%)	0(0%)	1
CHF	4(2.4%)	5(3%)	1
NYHA class III/IV	73(44.2%)	84(50.9%)	0.22
LVEF<50%	13(7.9%)	21(12.7%)	0.14
PASP >55mmHg	60(36.4%)	73(44.2%)	0.14
Preoperative AF	17(10.3%)	20(12.1%)	0.60
MV pathology			
Stenosis	49(29.7%)	38(23%)	
Regurgitation	89(53.9%)	101(61.2%)	0.33
Mixed	27(16.4%)	26(15.8%)	

BMI: Body mass index. PVD: Peripheral vascular disease. CVD: Cerebrovascular disease. DM: Diabetes mellitus. IDDM: Insulin-dependent diabetes mellitus. CHF: Congestive heart failure. NYHA: New York Heart Association. PASP: Pulmonary artery systolic pressure. LVEF: Left ventricular ejection fraction. AF: Atrial fibrillation. MV: Mitral valve

postoperative serum creatinine to 3 times the baseline or ≥4 mg/dl, urine output <0.3 ml/kg/h for 24 hours or anuria for 12 hours, or a new requirement for renal dialysis.

Postoperative pulmonary complications included: atelectasis, pleural effusion, respiratory failure, pneumonia, pneumothorax, bronchospasm, aspiration pneumonitis or prolonged mechanical ventilation > 48 hours. Sternal wound infection was defined by an evidence of superficial or deep sternal wound infection diagnosed within 30 days of the procedure or any time during the hospitalization for surgery. Deep sternal wound infection/mediastinitis was defined according to criteria of the Centers for Disease Control and Prevention [13].

Statistical analysis

Data analysis was performed using SPSS 20.0 (IBM Inc., Armonk, NY, USA) and R version 4.1.3 (The R Foundation for Statistical Computing). Categorical variables were presented as numbers and percentages while continuous variables were represented as means and standard deviations. Chi-square or Fisher exact tests were used to compare categorical data. The Shapiro-Wilk test was conducted to check the normality of continuous data. The T-student test was applied to compare continuous data if normally distributed, whereas the non-parametric Mann-Whitney U test was employed to compare data that were not normally distributed. Propensity score (PS) matching at a 1:1 ratio was applied to minimize the imbalance of preoperative covariates between male and female patient groups. To evaluate covariate balance before and after PS matching, standardized mean differences were calculated with values <0.10 being regarded as indicators of adequate covariate balance (Figure 1). To examine the relationship between female gender and postoperative outcomes, logistic regression analysis was conducted to find the odds ratio (OR) for outcomes and its 95% confidence interval (CI). A p-value of less than 0.05 was deemed significant.

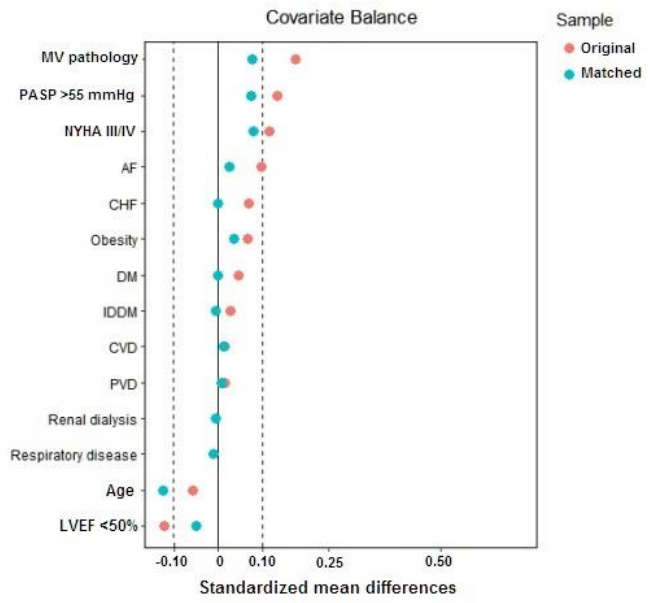

Figure 1: Balance dot plot shows standardized mean differences of preoperative covariates between genders in original and propensity score-matched samples. The plot shows good balance of preoperative covariates between male and female genders after propensity score matching; matched sample (the standardized mean differences of all covariates were <0.10). PVD: Peripheral vascular disease. CVD: Cerebrovascular disease. DM: Diabetes mellitus. IDDM: Insulin-dependent diabetes mellitus. CHF: Congestive heart failure. NYHA: New York Heart Association. PASP: Pulmonary artery systolic pressure. LVEF: Left ventricular ejection fraction. AF: Atrial fibrillation

Results

A total of 380 patients met the inclusion criteria of the study. All patients underwent cardiac surgery to treat rheumatic mitral valve disease. The majority of the patients were female (215/380; 56.57%) and the average age was 51.45±10.79 years. In terms of comparing the baseline demographic and clinical features between both genders (Table 1), there was a noticeable rise in the average age of female patients in the original sample, but this difference was not significant compared to the average age of male patients (52.68±11.62 vs 51.02±10.16 years, P = 0.16). Female patients showed a significant increase in the rates of previous congestive heart failure (P = 0.006), NYHA class III/IV (P = 0.03), reduced left ventricular ejection fraction (LVEF) defined as LVEF <50% (P = 0.001), pulmonary hypertension defined by pulmonary artery systolic pressure (PASP) >55 mmHg (P = 0.009), and a history of preoperative atrial fibrillation (P=0.01). The matched sample included 330 patients, with an equal number of male and female patients (n=165). The significant differences between male and female patients in the original sample (before PS matching) were no longer present in the matched sample (Table 2).

With respect to intraoperative data and postoperative outcome initial sample (Table 3), female patients experienced a significant longer hospital stay (9.30±3.55 vs 8.95±3.27, P = 0.02) and higher rates of postoperative complications (7% vs 2.4%, P = 0.04) as well as the overall adverse outcomes (7.9% vs 2.4%, P = 0.02). However, there was no noteworthy difference in operative mortality rates between the two genders (1.4% vs 0.6%, P = 0.63). In the matched sample, no significant differences were observed in postoperative results (Table 4).

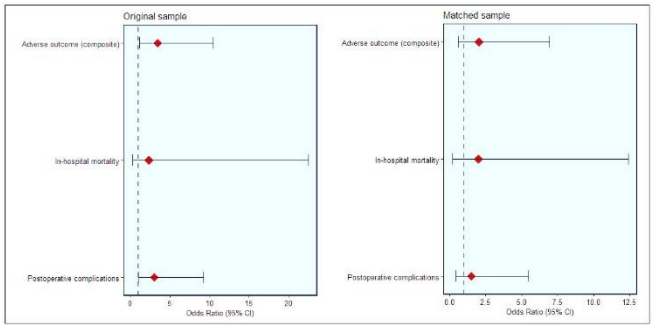

Figure 2: Forest plot showing odds ratio (OR) for the association between female gender and postoperative outcomes in the original and matched samples. OR: Odds ratio. CI: Confidence interval

Applying univariate logistic regression in the original sample (Figure 2), female gender associated with a significant increase in the odds for the overall adverse outcomes (OR: 3.45, 95%CI: 1.14 -10.47, P=0.02), while it did not show significant odds for the total incidence of postoperative complications (OR: 3.01, 95%CI: 0.98 -9.27, P = 0.054) or operative mortality (OR: 2.32, 95%CI: 0.23-22.51, P = 0.46). In the matched sample (Figure 2), there was no significant link between female gender and the incidence of postoperative complications (OR: 1.51, 95%CI: 0.42-5.48, P = 0.52), operative deaths (OR: 2.01, 95%CI: 0.18-12.41, P = 0.57), or the overall adverse outcomes (OR: 2.05, 95%CI: 0.60-6.94, P = 0.24).

Discussion

The findings of this study show acceptable operative mortality rates following posterior

Table 3: Comparing intraoperative data and postoperative outcome between male and female patients before matching

Variables	Male (n=165)	Female (n=215)	P-value
Bypass time (min)	69.29±20.08	67±22.32	0.14
Cross-clamp time (min)	44.80±13.66	42.67±14.75	0.055
Implanted valve size			
#25	44(26.7%)	37(17.2%)	0.16
#27	74(44.8%)	110(51.2%)	
#29	44(26.7%)	63(29.3%)	
#31	3(1.8%)	5(2.3%)	
Low cardiac output	76(46.1%)	101(47%)	0.85
Re-operation for bleeding	1(0.6%)	2(0.9%)	1
New onset AF	1(0.6%)	8(3.7%)	0.08
Pulmonary complications	1(0.6%)	2(0.9%)	1
Neurological complications (non-stroke)	3(1.8%)	2(0.9%)	0.65
Mediastinitis	0(0%)	1(0.5%)	1
Renal complications (non-dialysis)	1(0.6%)	1(0.5%)	1
ICU stay (days)	1.24±1.43	1.14±0.43	0.55
Hospital stay (days)	8.95±3.27	9.30±3.55	0.02*
Adverse outcome composite (Complications/Mortality)	4(2.4%)	17(7.9%)	0.02*
Complications	4(2.4%)	15(7%)	0.04*
Mortality	1(0.6%)	3(1.4%)	0.63

*Significant difference. AF: Atrial fibrillation

chordal preservation during isolated MVR in both males and females. Considering previous reports indicating a greater mortality risk for female patients after isolated MVR [1, 4], we can suggest that preserving the posterior chordae helps reducing or matching this risk with that of male patients. In addition, a higher rate of postoperative complications and longer hospital stays in clinically unmatched patients can be linked to greater rates of preoperative risk factors and co-existing health conditions among women.

To the best of our knowledge, there have been no prior studies evaluating the effect of female gender on the results of partial or complete preservation of the subvalvular chordae during MVR. We utilized propensity score matching to create two comparable gender groups and to reduce the influence of other preoperative risk factors on postoperative outcomes.

We regularly carry out posterior chordal preservation when suitable, due to its ease and the ability to implant the proper valve size. The function of subvalvular chordal preservation during MVR is related to the importance of the continuity between the mitral valve annulus and LV wall, which is involved in LV expansion during diastole and LV wall tension during systole. Removal of the subvalvular structure can disrupt this dynamic relationship, leading to issues in LV performance [14], while the preservation of this structure supports the ventricular function [9].

Since the initial use of posterior leaflet preservation in the 1960s led to a notable decrease in surgery-related mortality [15], many studies have been carried out to explore the clinical results of this method. Current evidence indicates that subvalvular preservation is better than non-preservation regarding postoperative low cardiac output, survival rates, and the duration of hospital stays [8, 16].

All of our patients had rheumatic causes of MV disease. Preserving the chordae in patients with rheumatic mitral valve disease can prevent postoperative LV size and geometry in patients with mitral regurgitation [17]. Additionally,

Table 4: Comparing intraoperative data and postoperative outcome between male and female patients after propensity-score matching

Variables	Male (n=165)	Female (n=165)	P-value
Bypass time (min)	69.29±20.08	67.70±23.29	0.28
Cross-clamp time (min)	44.80±13.66	42.89±14.43	0.12
Implanted valve size			
#25	44(26.7%)	29(17.6%)	0.38
#27	74(44.8%)	85(51.5%)	
#29	44(26.7%)	47(28.5%)	
#31	3(1.8%)	4(2.4%)	
Low cardiac output	76(46.1%)	72(43.6%)	0.65
Re-operation for bleeding	1(0.6%)	1(0.6%)	1
New onset AF	1(0.6%)	5(3%)	0.21
Pulmonary complications	1(0.6%)	1(0.6%)	1
Neurological complications (non-stroke)	3(1.8%)	0(0%)	0.24
Mediastinitis	0(0%)	1(0.6%)	1
Renal complications (non-dialysis)	1(0.6%)	0(0%)	1
ICU stay (days)	1.24±1.43	1.12±0.37	0.31
Hospital stay (days)	8.95±3.27	9.29±3.98	0.09
Adverse outcome composite (Complications/Mortality)	4(2.4%)	8(4.8%)	0.23
Complications	4(2.4%)	6(3.6%)	0.52
Mortality	1(0.6%)	2(1.2%)	0.56

AF: Atrial fibrillation

chordal preservation helps maintain LV ejection fraction over time in patients with rheumatic valve disease [18]. However, there is a debate about the long-term advantages of chordal preservation in rheumatic patients because of later poor outcomes after MVR, especially in those with rheumatic mitral valve stenosis [19, 20].

In literature, there is a lack of research looking at gender-specific results following partial or total chordal preservation during MVR. Many studies have looked into gender differences in mortality rates after MVR, regardless of chordal preservation. Studies indicate that women typically show higher postoperative mortality rates than men [1, 4, 21]. Factors like smaller heart size, higher occurrence of co-morbidities, and differences in biological reactions to cardiac surgery might account for this difference [22, 23].

In the current research, we found no notable differences in operative mortality rates between males and females either before or after adjusting for preoperative factors (0.6% vs. 1.4%, and 0.6% vs. 1.2%, respectively). There are no similar studies in the literature to relate to these results, while these rates are reasonable and lower than mortality rates found in other studies following MVR, irrespective of chordal preservation. Bradley et al. [4] found an overall mortality rate of 5.1% for female patients compared to 3.8% for male patients, showing a notable difference in unmatched groups after open cardiac valve surgery. Additionally, female gender associated with a higher likelihood of in-hospital death after adjusting for other factors. In the research by Wong et al. [1], female gender was significantly linked to occurrence of in-hospital adverse events (9.4% vs. 8.3%, $P < 0.001$), primarily influenced by overall mortality (5.2% vs. 4.3%, $P < 0.001$). In the recent study by Chang et al [5], females showed a marginally higher risk of in-hospital mortality compared to males following mitral valve surgery.

In the current study, a significant increase in the overall incidence of postoperative complications was observed in female patients prior to adjusting for preoperative factors (7% vs.

2.4%, P=0.04), which became insignificant after adjustment (3.6% vs. 2.4%, P=0.52). These figures are lower than the previously reported gender-specific results of MVR whether chordal preservation is considered or not. In the research conducted by Bradley et al. [4], the rates of any complication were 53.1% in male patients and 55.4% in female patients, showing a significant difference (P < 0.001) in the unmatched groups. Additionally, Wong et al. [1] found a higher overall complication rate in women (37.9% vs. 35.3%, P < 0.001). The decrease in major adverse events during hospitalization and all-cause mortality was dependent on time, irrespective of gender.

Ongoing research is essential to enhance understanding of gender-related results after MVR. Better risk evaluation and customized treatments are important factors to improve survival rates. In addition, prolonged follow-up studies are needed to evaluate the influence of gender on late deaths, valve deterioration, and the requirement for re-operations to further develop patient care approaches.

Limitations

This study has potential limitations including its retrospective design, single-center analysis, specifically assessing partial chordal preservation, and a higher occurrence of rheumatic causes of mitral valve disease in the study group, which suggests that the findings should be interpreted carefully in light of degenerative mitral valve disease.

Conclusion

In conclusion, preserving the posterior chordal apparatus can lower the risk of operative mortality in female patients receiving MVR. Higher preoperative health issues may account for higher rates of postoperative complications and longer hospital stay in female patients. Balancing the preoperative factors between both gender groups leads to non-significant differences in the length of hospital stay and overall incidence of postoperative complications. Therefore, female patients should gain survival advantages from posterior chordal preservation during MVR for rheumatic valve disease, regardless of their preoperative risk profile. Nonetheless, more research is needed to assess the effect of gender on MVR outcomes and chordal preservation, emphasizing the need for prospective, large-scale, and long-term studies.

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