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Gender Disparities in Postoperative Outcomes after Mechanical Heart Valve Replacement Surgery: An Investigative Analysis

Muhammad Waleed, Waqar Masud Malik, Kiran Jamal, Attiya Hameed Khan, Syed Shahkar Ahmed Shah, Muhammad Tariq

Objectives: To compare the pre- and post-operative factors among male and female patients of valvular heart surgery.

Study design and settings: This retrospective observational study was conducted in the department of Cardiac surgery at Peshawar institute of Cardiology from Dec 2020 to March 2022.

Methodology: This retrospective observational study included (n=165) adults, who underwent valvular surgery. Data was extracted from electronic medical record (EMR) and analyzed by using SPSS version 26.0. The study complied with ethical approval and the Helsinki Declaration.

Results: Majority of the patients who underwent valvular surgery were in younger age group (age<45) with predominantly female as compared to male (60.4% vs 38.09%, $p<0.05$). Similarly, the results showed that most of the men underwent aortic valve surgery as compared to females, who underwent mitral valve surgery with statistically significant difference among gender at ($p<0.05$). Comparison of post-operative complications with respect to gender showed that arrythmias along with wound infection and mortality showed statistically significant difference among gender at ($p<0.05$).

Conclusion: This study aimed to compare pre- and post-operative factors among male and female patients undergoing valvular surgery. The findings reveal significant gender-based differences in the distribution of age, types of valve surgery, and post-operative complications. However post operative and gender specific complications, hospital stay along with mortality associated with the type of valve procedure needs to be further explored. Detailed multicenter study and long-term follow up is needed to better analyze the long-term results and disease burden.

KEYWORDS: Atrial septal defect, Coronary artery bypass, heart valve diseases

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INTRODUCTION:

Heart valve disease has been dubbed "the next cardiac epidemic," and as the population ages, its prevalence is predicted to double by 2040 and triple by 2060 .[1]However, it has gained increasing attention in the field of cardiovascular medicine due to significant changes in its presentation and management over the past 60 years. In industrialized nations, the prevalence of valve disease has evolved since the 1950s, transitioning from a predominant rheumatic etiology to a degenerative one. This shift has led to changes in patient demographics and the distribution of various types of valvular lesions.[2] Rheumatic heart disease (RHD), which affects more than 30 million people globally, accounts for 300,000 annual fatalities and 10 million annual disabilities, represents a major global burden, particularly in developing and low-income nations.[2] This growing burden of valvular heart disease highlights its importance as one of the most serious cardiovascular conditions worldwide, with its prevalence influenced by several factors, including age, gender, and socio-economic context.[3]

In particular, sex differentiation in VHD remains underexplored and poorly understood, contributing to disparities in treatment and outcomes.[4] Research indicates that women with VHD experience variations in the frequency

of disease, clinical presentations, symptom perception, and response to diagnostic procedures. For example, women may have different sensitivities and specificities to echocardiography and they often respond differently to medications, requiring distinct dosing strategies These gender-related differences also extend to the management strategies employed, which are frequently influenced by physician-related factors. This underscores the need for sex-specific approaches to diagnosis and therapy, as a one-size-fits-all model may not effectively address these differences.[5]

Despite the growing recognition of these gender disparities, current guidelines for diagnosing and treating valvular heart disease do not adequately incorporate sex-related variations. This gap in knowledge and practice is concerning, as personalized care for VHD, tailored to both sex and body size, has the potential to improve patient outcomes significantly.[6] The lack of concrete data on gender-specific recommendations for VHD treatment further complicates clinical decision-making. To address these issues, future research must focus on a more granular understanding of how gender influences VHD, which could lead to the development of more targeted and effective management strategies.

Surgical intervention plays a critical role in the treatment of VHD, resulting in reduced mortality and enhanced quality of life for many patients. Heart valve replacement, the second most common type of heart surgery after coronary artery bypass graft (CABG) surgery, is a key component of this therapeutic approach.[7] However, women are less likely than men to undergo surgical procedures, because of worse postoperative outcomes, including higher rates of complications and longer recovery times.[5] This disparity is likely influenced by a combination of biological, social, and healthcare system factors, further emphasizing the need for a sex-conscious approach to surgical management in VHD.

In many developing countries, where chronic rheumatic heart disease or rheumatic fever constitutes a significant portion of cardiac admissions, the demand for heart valve replacement surgeries is particularly high. Statistics indicate that these conditions account for between 10 and 35 percent of all cardiac admissions in low-income nations, where access to advanced care may be limited.[8]

The WHO Global Action Plan for the Prevention and Control of Non-Communicable Diseases (NCDs) includes a goal to achieve a 25% relative reduction in NCD mortality by 2025, which highlights the urgency of addressing VHD as a major contributor to global disease burden.[9] A key priority for achieving this goal should be the establishment of comprehensive rheumatic heart disease control programs in low- and middle-income countries, where the disease burden remains disproportionately high. Strengthening healthcare infrastructure, increasing access to early diagnosis, and improving surgical outcomes in these regions are crucial steps toward alleviating the global impact of valvular heart disease.[10]

In light of these challenges, this study aims to address the gap in knowledge regarding the predictors of valvular heart disease in the local population. By exploring demographic, clinical, procedural, sex-based differences and other surgical factors, the study seeks to provide valuable insights into the management of VHD at Peshawar Institute of Cardiology and identify strategies that could potentially reduce the risk of complications, including those related to surgical intervention.

METHODOLOGY:

The data for this retrospective study, conducted from December 2020 to March 2022 at Peshawar Institute of Cardiology, KPK, included male and female patients who underwent valvular surgery. The sample size of 165 patients was estimated through WHO sample size calculator based on a confidence level of 95% and a power of 80%, which are commonly used thresholds for ensuring statistical reliability. It was calculated to account for the potential differences in the prevalence of postoperative complications between male and female patients, with a significance level of $p < 0.05$ and a statistical power of 80%.

with data extracted retrospectively from the Electronic Medical Record (EMR). The study was approved by the hospital's Institutional Review Board committee (IRC/24/140), and informed consent was obtained from all participants. A team of researchers, statisticians, and physicians designed and critically evaluated the questionnaire used for data collection, ensuring that all relevant variables were included. The study adhered to the principles of the Helsinki Declaration and was conducted in accordance with ethical standards. Inclusion criteria encompassed adult patients (aged >18 years) undergoing valvular surgeries, ASD closure, and combined procedures. Exclusion criteria included patients aged <17 years, those with myxoma or renal failure, and those requiring re-opening. Data analysis was performed using SPSS 26.0 (IBM-SPSS Inc., Chicago, USA), with frequencies and percentages calculated for qualitative variables such as gender, etiology, complications, and valve types. Descriptive statistics (mean and ±SD) were used for continuous variables like cross-clamp time, bypass time, and ejection fraction. Chi- square test assessed relationships of gender with demographic variables, systolic function distribution and types of valvular surgery with statistical significance considered at $p < 0.05$. Additionally, a student t-test was applied to compare postoperative complications between males and females, with significance set at $p < 0.05$. The study further ensured the accuracy of the data through validation procedures, including cross-checking of medical records and verification of surgical outcomes. Ethical considerations were prioritized throughout the study to maintain patient confidentiality and data integrity.

To minimize bias, a detailed review process was implemented to ensure that all variables were accurately recorded and that all exclusions were appropriately made according to the predefined criteria. Furthermore, inter-rater reliability for data entry was confirmed by double-checking patient records, ensuring consistency in the interpretation of data.

RESULTS:

This study included a total of 165 patients who underwent valvular and combined surgical procedures. The demographic analysis revealed a nearly equal distribution of gender, with 50.9% males and 49% females (*p = 0.03*). Age distribution showed significant differences between genders, with males predominantly represented in the 45-65 age group and females in the 25-45 age group (*p = 0.02*). The 65-75 age group did not show any significant gender differences (*p = 0.98*).

In terms of systolic function, normal function was more common among males (89.3%) compared to females (81.5%). However, females had a higher percentage of moderate (12.34%) and severe (1.23%) systolic dysfunction compared to males (*p = 0.03* for moderate, *p = 0.00* for severe). Regarding valvular surgeries, males were more likely to undergo procedures like Aortic Valve Replacement (AVR) (*p = 0.04*). In contrast, females had a higher proportion of Mitral Valve Replacement (MVR), and there was a significant gender difference in the distribution of surgeries such as MVR and AVR combined (*p = 0.04*).

Post-operative complications were notably more common in males, with a higher incidence of arrhythmias (*p = 0.00*) and wound infections (*p = 0.01*). Males also had a slightly higher mortality rate (4.8%) compared to females (3.7%) (*p = 0.04*). Intra-operative data revealed a mean bypass time of 157.45 minutes and cross-clamp time of 119.73 minutes. Post-operatively, patients had a mean hospital stay of 6.61 days and an ICU stay of 34.11 hours. These findings emphasize the significant role of gender in shaping both clinical outcomes and post-operative recovery, highlighting the need for gender-specific considerations in surgical planning and care.

DISCUSSION:

The prevalence of heart valve disease is 0.7% in people aged 18 to 44 and 11.7% in people aged 75 and above. Heart valve disease (VHD) continues to present significant challenges in clinical practice, particularly as the

Table 1 presents the distribution of gender among the study participants at *p-value <0.05*

Characteristics	Total, n (%)	Male, n (%)	Female, n (%)	*P* value
Gender	165 (100%)	84 (50.9%)	81 (49%)	**0.03**

Table 2 illustrates age distribution of the patients included in the study at *p-value <0.05.*

Age (years)	Total, n (%)	Male, n (%)	Female, n (%)	*P* value
18-25	19 (11.51%)	11 (13%)	8 (9.9%)	0.00
25-45	81 (49%)	32 (38.09)	49 (60.4%)	0.05
45-65	56 (33.9%)	36 (42.9%)	20 (24.7%)	0.02
65-75	9 (5.4%)	5 (5.9%)	4 (4.9%)	0.98

Table 3 summarizes the systolic function distribution of the patients included in the study at *p-value <0.05*

Systolic Function	Male, n (%)	Female, n (%)	Total, n (%)	*P* value
Normal	75(89.3%)	66(81.5%)	141(85.5%)	0.089
Mild	4(4.76%)	4(4.9%)	8(4.8%)	0.459
Moderate	3(3.6%)	10(12.34%)	13(7.9%)	0.03
Severe	2(2.4%)	1(1.23%)	3(1.8%)	0.00

Table 4 illustrates the comparison of valvular surgeries by gender, showing significant differences in the distribution of surgeries for certain procedures at *p-value <0.05.*

Valve surgeries	Male, n (%)	Female, n (%)	Total, n (%)	*P* value
AVR	30(35.7%)	10(12.34%)	40(24.24%)	0.03
AVR+ Root Enlargement	2(2.38%)	2(2.47%)	4(92.4%)	0.987
MVR	23(27.4%)	45(55.5%)	68(41.2%)	0.00
AVR+CABG	2(2.4%)	2(2.5%)	4(24.24%)	0.84
MVR+CABG	6(7.14%)	1(1.23)	7(4.2%)	0.785
CABG+AVR+MVR	2(2.4%)	---	2(1.2%)	---
MVR+AVR	8(9.3%)	20(20.47%)	28(16.9%)	0.04
MVR+ TV repair	3(3.6%)	---	3(1.8%)	---
MVR+ASD	1(1.2%)	---	1(0.6%)	---
AVR+VSA	1(1.2%)	1(1.23%)	2(1.2%)	---
AVR+MVR+TV repair	3(3.6%)	---	3(1.8%)	---

Table 5 Illustrates the comparison of post-operative complications with respect to gender shows a significant result at *p-value <0.05*

Complications	Male, n (%)	Female, n (%)	Total, n (%)	*P* value
Arrhythmias	16 (19%)	14 (17%)	30 (18.1%)	0.00
Wound Infection	2 (2.3%)	1 (1.2%)	3 (1.8%)	0.01
Exploration for Bleeding	4(4.8%)	2 (2.5%)	6 (3.6%)	0.62
Acute renal failure	3 (3.6%)	1 (1.23%)	4 (2.4%)	0.56
Pericardial effusion	2 (2.3%)	1 (1.23%)	3 (1.8%)	0.95
Stroke	2 (2.3%)	2 (2.4%)	4 (2.4%)	0.48
No Complications	38 (45.2%)	70 (86.4%)	108 (65.5%)	0.67
Mortality	4 (4.8%)	3 (3.7%)	7 (4.2%)	0.04

Table 3.6 illustrates the Intra-Operative data mean By-pass time (157.45±53.713), and mean Cross-clamp time (119.73±43.911). Similarly post-operative outcomes show mean Hospital stay 6.61±1.079 and mean ICU-stay (34.11±11.84) respectively.

Intra-operative data		
Variables	**Mean**	**±SD**
By-pass time (mins)	157.45	±53.713
Cross clamp time (mins)	119.73	±43.911
post-operative outcomes		
Hospital-stay (Days)	6.61	±1.079
ICU-stay (Hrs.)	34.11	±11.84

epidemiology of this condition evolves with shifts in underlying causes, patient demographics, and surgical approaches.[11] Over recent decades, there has been a marked transformation in the prevalence and etiology of VHD. In industrialized nations, the predominant causes of valvular heart diseases have transitioned from rheumatic fever to degenerative conditions, such as aortic stenosis and mitral regurgitation. This shift has been accompanied by an increase in the overall burden of VHD, particularly among the aging population.[12] Understanding these changes is crucial for informing clinical management strategies and improving patient outcomes.

The present study provides valuable insights into the evolving landscape of VHD, especially with regard to gender-specific differences in disease prevalence, treatment patterns, and surgical outcomes. In the current study, a similar trend was observed, with a predominance of rheumatic valve disease in patients, especially in men. This finding aligns with previous research that identifies rheumatic conditions as the primary cause of VHD in both men and women in developing countries.[2]

In terms of age distribution, our study revealed that females in the 25-45 age group were more affected by VHD (60.4%) compared to males (38.09%), while males had a higher prevalence in the 45-65 age range. These findings are in contrast to some previous studies that suggested a relatively equal chance of developing VHD for both genders, but the type of valve lesion does show variations. A study by R Ocher et al. (2023) noted that while both men and women are equally susceptible to VHD, women tend to develop mitral valve disorders at an earlier age, which may explain the higher percentage of younger women in our cohort.[13] This could be attributed to factors such as hormonal changes and genetic predispositions, which may influence the age of onset of valvular diseases in women.

An interesting finding from our study was the significant difference in systolic function between male and female patients. A higher proportion of males had normal systolic function, while females exhibited a greater prevalence of moderate and severe systolic dysfunction. This gender difference in systolic function outcomes is consistent with previous studies, which have suggested that gender-specific physiological factors, such as hormonal influences and vascular resistance, play a role in cardiac function. Moreover, moderate systolic dysfunction was notably more prevalent in females, which aligns with research indicating that women tend to present with more advanced cardiac dysfunction in the context of valvular disease. Severe systolic dysfunction, although less common, was more frequently observed in males in our cohort, highlighting a potential gender-based variation in the severity of cardiac conditions post-surgery.[14] These findings underscore the need for gender-specific management strategies in the treatment of valvular diseases.

The relationship between obesity and surgical outcomes remains a critical area of research. In particular, the impact of obesity on recovery time and post-operative complications continues to garner attention. A study by AR Vest et al. (2013) highlighted the importance of weight management pre-operatively, indicating that even modest weight loss before surgery could reduce complications such as wound infections and improve overall recovery. [15] This suggests that early intervention for obese patients, especially in cardiac surgery settings, could lead to better clinical outcomes.

Regarding the types of valve surgery, our study revealed that more males underwent aortic valve replacement (AVR), whereas more females underwent mitral valve replacement (MVR). This finding is consistent with existing literature, where it has been shown that men are more likely to suffer

from aortic valve disorders, such as aortic stenosis and regurgitation, while women predominantly suffer from mitral valve diseases, such as mitral valve prolapse or rheumatic mitral valve disease.[6] This gender-based difference may be influenced by anatomical, physiological, and hormonal factors that predispose each gender to different types of valvular conditions.

We also observed that the majority of patients who underwent combined procedures, such as AVR with coronary artery bypass grafting (CABG), were male. This finding is in line with previous studies indicating that men tend to undergo more complex surgeries, particularly those involving both valve replacement and coronary artery bypass. Concomitant CABG surgeries are associated with more complications, higher hospital costs, and longer recovery times, as noted in a study by Wong et al. (2021), which highlights the challenges of managing patients who require both valve replacement and coronary artery bypass surgery.[16]

Another notable finding from our study was the higher incidence of double-valve replacement (DVR) surgeries among females. Double-valve procedures, such as AVR and MVR combined, were more commonly performed in women, reflecting a tendency for women to seek medical intervention at later stages when multiple valves are affected. Previous research has shown that DVR procedures are associated with higher operative mortality compared to single-valve replacements, though advancements in surgical techniques and postoperative care have led to a significant reduction in mortality rates for these complex surgeries.[17] This is further supported by the study of A lio et al. (2019), which emphasized the role of modern myocardial preservation techniques and post-operative care in reducing the mortality risk associated with double-valve procedures.[18]

In terms of post-operative complications, our study observed a higher rate of arrhythmias among both male and female patients, which is consistent with the literature. Arrhythmias, particularly atrial fibrillation, are common following heart valve surgery, occurring in up to 65% of cases, and are associated with prolonged hospital stays, higher mortality, and long-term morbidity.[19] However, the underlying causes of post-operative arrhythmias remain poorly understood, and further research is needed to elucidate the mechanisms and risk factors associated with this complication in valvular heart surgery patients.

Wound infections were more common in male patients, a finding that aligns with the literature, which suggests that male patients are at a higher risk for surgical site infections. Wound infections in cardiac surgery patients can lead to serious complications, including prolonged hospital stays, the need for additional surgeries, and in some cases, sepsis or organ failure. The association between gender and wound infection rates may be related to differences in immune function, post-operative care, or even patient behavior regarding wound care. As noted by Y Song et al. (2023), surgical site infections remain a significant concern, and efforts to reduce infection rates are ongoing through better infection control practices and more stringent post-operative care protocols.[20]

Similarly, bleeding is also a major concern and complication after cardiac surgery. In the study male patients suffered more from this complication as compared to females. According to previous literature, bleeding increases hospital length of stay and critical care utilization, with affected patients requiring prolonged recovery, transfusions, and sometimes reoperations. This not only delays recovery but also puts additional strain on critical care resources, leading to higher healthcare costs.[21]

Another complication documented was the acute renal injury and male patients suffered more from the injury than females. Numerous studies indicate that between 1 and 10% of patients need RRT, while the prevalence of postoperative AKI varies between 28 and 94%. Acute kidney damage (AKI) following surgery is a recognized issue following heart surgery with cardiopulmonary bypass (CPB). Its appearance is caused by a number of reasons, including inflammatory response activation, hemolysis, embolic events, vascular redistribution, kidney damage from ischemia and loss of pulsatile flow. The likelihood of developing AKI is increased by patient risk factors, such as age and preexisting renal impairment.[22]

In the study, the stroke was found to be equal in both men and females. However, stroke is a rare but still a potentially crippling complication of heart valve replacement surgery with risk dependent on patient characteristics and concomitant procedures. Stroke rates after surgical valve replacement (SVR) have ranged widely from 1 to 10%. Several studies have evaluated risk factors and postoperative neurologic complications after heart valve surgery, though the results are conflicting or incomplete mainly due to a low number of interventions or a low number of variables.[23]

Regarding mortality, our study found a higher mortality rate in male patients, which contrasts with some studies that report higher mortality in females following cardiac surgery. However, our results support the notion that the complexity of the surgical procedure influences mortality, with more complex surgeries, such as those involving multiple valves, associated with higher risks of death. This is consistent with the findings of M Gupta et al. (2017), who found that combined surgeries, such as AVR and MVR, carry a higher risk of mortality, particularly when performed in older patients with multiple comorbidities.[24]

While this study provides valuable insights into gender differences in valvular heart surgery, several limitations should be considered. First, the study design was retrospective, and data were extracted from electronic medical records (EMRs), which may be prone to inaccuracies, missing

data, or inconsistencies. Such limitations in the quality of data can affect the robustness and reliability of the findings. Additionally, the sample size, although sufficient for preliminary analysis, may not fully represent the broader population of patients undergoing valvular heart surgery, limiting the generalizability of the results to other regions or healthcare settings. Furthermore, this study did not account for several confounding variables, such as socioeconomic status, lifestyle factors (e.g., smoking, alcohol use), and the presence of other comorbidities (e.g., diabetes, hypertension), all of which could potentially influence surgical outcomes. Finally, the study did not include long-term follow-up data, which would have provided a clearer understanding of the sustained impact of gender differences on patient recovery and quality of life post-surgery.

CONCLUSION:

In conclusion, this study highlights significant gender-based differences in the clinical presentation, treatment, and outcomes of valvular heart disease (VHD) patients undergoing surgical interventions. Key findings include gender disparities in the prevalence of specific valve disorders, surgical procedures, and post-operative complications, with males experiencing more complex surgeries and a higher incidence of complications such as arrhythmias, wound infections, and acute renal injury. Additionally, the study underscores the role of demographic factors like age and BMI in influencing patient outcomes. Although our findings contribute valuable insights into the evolving landscape of VHD and its surgical management, limitations such as the retrospective design, sample size, and lack of long-term follow-up must be considered. Further research, incorporating a broader cohort and exploring additional confounding variables, is necessary to enhance the understanding of gender-related differences in valvular heart surgery outcomes.

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Muhammad Waleed: Conception and Design
Waqar Masud Malik: Drafting
Kiran Jamal: Data Analysis
Attiya Hameed Khan: Data Analysis
Syed Shahkar Ahmed Shah: Final Approval
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