Journal of Health and Rehabilitation Research 2791-156X JHRR

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Original Article

Frequency of Aortic Root Enlargement to Prevent PPM Patients Undergone Aortic Valve Replacement in Peshawar Institute of Cardiology

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Conflict of Interest: None.

Nasir A., et al. (2024). 4(1): DOI: https://doi.org/10.61919/jhrr.v4i1.415

ABSTRACT

Background: Surgical aortic valve replacement (AVR) remains the gold standard for treating symptomatic aortic valve stenosis, aiming to alleviate left ventricular overload, relieve symptoms, and enhance survival. Aortic root enlargement (ARE) is a technique used alongside AVR to accommodate a properly sized prosthetic valve, particularly in patients with a small aortic annulus, to prevent patient-prosthesis mismatch (PPM) and improve clinical outcomes.

Objective: This study aimed to evaluate the outcomes of AVR with or without ARE at the Peshawar Institute of Cardiology, focusing on the procedural efficacy, incidence of PPM, and short-term post-operative outcomes.

Methods: A retrospective analysis was conducted on 76 patients who underwent AVR, with or without ARE, from December 2020 to March 2023. Data were collected on demographics, clinical manifestations, etiology, comorbidities, operative details, and post-operative outcomes. Statistical analyses included mean ± SD for quantitative variables and frequencies with percentages for qualitative variables, using SPSS 26.0 for data analysis.

Results: The average age of patients was 37.53 ± 15.589 years, with a mean BMI of 24.9125 ± 5.07249. Among the procedures, 48.7% were AVR alone, 11.8% AVR with ARE, 10.5% AVR with coronary artery bypass grafting (CABG), and 28.9% AVR with mitral valve replacement (MVR). The mean bypass time for AVR+ARE was 189.3333 ± 77.83155 minutes, compared to 161.9254 ± 64.08737 minutes for other valvular surgeries. Post-operative hospital stay averaged 5.4444 ± 1.74005 days for AVR+ARE cases, against 6.52 ± 2.003 days for other surgeries.

Conclusion: AVR with ARE is a feasible and effective strategy for patients with small aortic annuli, demonstrating satisfactory short-term outcomes and potential to reduce PPM. The study highlights the need for cardiac surgeons to gain proficiency in ARE techniques and calls for further research to evaluate long-term outcomes.

Keywords: Aortic valve replacement (AVR), Aortic root enlargement (ARE), Patient-prosthesis mismatch (PPM), Cardiac surgery, Short-term outcomes, Peshawar Institute of Cardiology.

INTRODUCTION

Aortic root enlargement (ARE) represents a pivotal surgical technique utilized during surgical aortic valve replacement (SAVR) to accommodate the placement of a prosthetic valve of appropriate size in patients afflicted with aortic valvular diseases (1, 2). This technique aims to circumvent the incidence of patient-prosthesis mismatch (PPM), a condition characterized by left ventricular outflow obstruction due to a prosthetic valve whose effective orifice area (EOA) is inadequate relative to the patient's body size (3, 4). The concept of PPM was first delineated by Rahimtoola, highlighting the mismatch anomaly wherein the EOA of the implanted prosthesis falls short of meeting the physiological demands dictated by the patient's body surface area (BSA). Following Rahimtoola's groundwork, Pibarot and Dumesnil further classified PPM into moderate and severe categories, based on indexed EOA to BSA, with thresholds set at 0.85 cm2/m2 and <0.65 cm2/m2, respectively (5-7).

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The surgical community recognizes four principal techniques for performing ARE, namely the Manouguian, Nick, Nunez, and Kanno-Rastan procedures, with the Nick's technique being the pioneering method. This technique particularly addresses the challenge of a small annulus by enlarging the aortotomy through the noncoronary sinus and incorporating a patch to expand the annulus, thereby facilitating the placement of a larger valve and diminishing the risk of PPM (8, 9). Despite the procedural variety, there exists a paucity in literature examining the comparative outcomes associated with each technique, as well as an ongoing debate regarding the potential complications inherent to ARE, including extended cardiopulmonary bypass and aortic cross-clamp times, paraprosthetic leakage, aneurysm formation, suture line disruption, sub-annular hemorrhage, and patch dislodgement (10, 11).

Notwithstanding these concerns, ARE has been validated to alleviate the elevated transvalvular pressure gradient, reduce left ventricular mass, and enhance the overall benefits conferred by AVR. The procedure's primary indication is the prevention of significant PPM, which could adversely affect cardiac output (12, 13). Furthermore, ARE finds application in preparing patients for valve-in-valve transcatheter AVR by allowing for the insertion of a larger percutaneous valve, albeit its recommendation is reserved for those with a small aortic annulus and favorable long-term survival prospects (14, 15).

The study conducted at the Peshawar Institute of Cardiology in KPK addresses the underutilization of surgical ARE among surgeons, attributed to various concerns. By undertaking a retrospective analysis, the research aimed to underscore the significance of the ARE technique in managing small aortic annuli to prevent PPM and to elucidate the post-operative outcomes of patients subjected to aortic valve surgery in conjunction with ARE. This inquiry serves to reinforce the value of ARE in enhancing patient care within the realm of aortic valve disease treatment, amidst the backdrop of surgical innovation and evolving clinical practice paradigms (16, 17).

MATERIAL AND METHODS

In this retrospective study, data were collected from December 2020 to March 2023 at the Peshawar Institute of Cardiology, KPK, to evaluate the outcomes of aortic valve replacement (AVR) procedures, with a particular focus on the impact of aortic root enlargement (ARE) on patient-prosthesis mismatch (PPM) prevention and post-operative outcomes. The study cohort comprised 76 patients, both male and female, who had undergone AVR with or without the ARE procedure, including those who had other combined surgeries. Data were extracted retrospectively from the electronic medical records (EMR) of the patients. Ethical approval for the study was obtained from the hospital's Institutional Review Board (IRB), ensuring adherence to the ethical principles outlined in the Declaration of Helsinki for medical research involving human subjects. In line with ethical guidelines, verbal informed consent was secured from all participants included in the study to utilize their medical records for research purposes (18).

The inclusion criteria for the study were adults of either gender, aged greater than 16 years, who underwent AVR alone or in combination with ARE, and who had a left ventricular ejection fraction (LVEF) greater than 30%. Exclusion criteria were set to omit patients older than 70 years and those with chronic kidney disease (CKD), aiming to minimize confounding factors that could influence the outcomes of interest (19).

For the analysis of the collected data, the Statistical Package for the Social Sciences (SPSS) version 26.0 (IBM-SPSS Inc., Chicago, USA) was employed. The analysis encompassed both qualitative and quantitative variables. Frequencies and percentages were calculated for qualitative variables, including gender, geographic location, medical history, clinical manifestations, etiology of the valvular disease, details of the surgical procedure, operative status, New York Heart Association (NYHA) classification, and post-operative complications (20, 21). Descriptive statistics, specifically means and standard deviations (±SD), were used to analyze quantitative data. This methodological approach facilitated a comprehensive examination of the surgical interventions and their outcomes, enabling a nuanced understanding of the efficacy and safety of AVR and ARE in the studied population.

RESULTS

The retrospective study conducted at the Peshawar Institute of Cardiology, involving 76 patients, revealed insightful baseline clinical characteristics and outcomes associated with aortic valve replacement (AVR) procedures, including instances where aortic root enlargement (ARE) was utilized. According to Table 1, the average age of participants was 37.53 years, with a standard deviation of 15.589, indicating a wide age range within the study population. The mean pulse rate was observed at 84.7368 beats per minute, with variability (SD = 16.58865), underscoring the physiological diversity among the subjects. The body mass index (BMI) averaged at 24.9125 kg/m^2 (SD = 5.07249), and the body surface area (BSA) mean was 1.9607 m^2, though with a high standard deviation (SD = 2.28518), suggesting significant differences in body sizes across the cohort.

Diving into the demographic profile and clinical characteristics as detailed in Table 2, a predominant majority of the patients undergoing other valvular surgeries were male (68.7%), while a more balanced gender distribution was noted in the AVR+ARE subgroup, with males constituting 33.3% and females 66.7%. The clinical manifestations varied widely, with palpitations being the most common symptom (28.9%), followed by vomiting (25%) and shortness of breath with palpitations (15.8%). In terms of etiology,

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rheumatic causes were predominant (48.7%), highlighting the significant impact of rheumatic heart disease in this population. Comorbidity profiles revealed that 25% of patients had no comorbid conditions, while hypertension (26.3%) and diabetes mellitus (9.2%) were notable among those that did.

The procedural distribution, as outlined in Table 3, showed that nearly half of the patients (48.7%) underwent AVR alone, while a smaller fraction underwent AVR combined with ARE (11.8%), indicating selective application of root enlargement techniques. Other combined procedures like AVR+CABG and AVR+MVR represented 10.5% and 28.9% of the surgeries, respectively, illustrating the complexity of cases managed and the need for individualized surgical approaches.

Table 1: Baseline Clinical Characteristics of the Study Population (n=76)

Characteristics	Mean	SD
Age (years)	37.53	±15.589
Pulse Rate (/min)	84.7368	±16.58865
BMI (kg/m^2)	24.9125	±5.07249
BSA (m^2)	1.9607	±2.28518

Table 2: Demographic Profile, Clinical Manifestation, Etiology, Comorbidities, and CCS/NYHA Class (n=76)

Variables	Frequency (n)	Percentage (%)
Gender (Other Valvular Surgeries)		
Male	46	68.7%
Female	21	31.3%
Gender (AVR+ARE)		
Male	3	33.3%
Female	6	66.7%
Clinical Manifestation		
Chest Pain	6	7.9%
Vomiting	19	25%
Palpitation	22	28.9%
Shortness of Breath	10	13.2%
Shortness of Breath + Palpitation	12	15.8%
Shortness of Breath + Chest Pain	7	9.2%
Etiology		
Rheumatic	37	48.7%
Degenerative	18	23.7%
Congenital	16	21.1%
Infective	5	6.6%
Comorbidities		
None	19	25%
Hypertension	20	26.3%
Diabetes Mellitus	7	9.2%
Hypertension + Diabetes Mellitus	7	9.2%
Smoking	3	3.9%
Stroke	1	1.3%
Endocarditis	2	2.6%
Family History	7	9.2%
Myocardial Infarction	2	2.6%
Any Previous Surgery	1	1.3%
Coronary Angiography	2	2.6%
Ischemic Heart Disease	5	6.6%
CCS/NYHA Class		

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Variables	Frequency (n)	Percentage (%)
CCS/NYHA-II	42	55.3%
CCS/NYHA-III	31	40.8%
CCS/NYHA-IV	3	3.9%

Table 3: Frequency of Aortic Valve Surgery and Aortic Root Enlargement Procedures (n=76)

Procedures	Frequency (n)	Percentage (%)
AVR	37	48.7%
AVR + ARE	9	11.8%
AVR + CABG	8	10.5%
AVR + MVR	22	28.9%

Table 4: Pre-Operative Lab Reports, Echocardiographic Measurements, Intra-Operative Data, and Post-Operative Outcomes

Variables	Mean	SD
Pre-Op Lab Reports		
Haemoglobin (g/dL)	12.4826	±2.22106
Creatinine (mg/dL)	0.8385	±0.27113
Echocardiographic Measurements		
Aortic Annulus (mm)	23.3224	±4.13659
LV Diastolic Diameter (mm)	48.7500	±8.75766
LV Systolic Diameter (mm)	36.5000	±8.48450
Interventricular Septum (mm)	11.9737	±2.19681
Ejection Fraction (%)	58.1447	±2.13159
Valve Size (Other Valvular Surgeries)	22.0597	±2.08807
Valve Size (AVR+ARE)	20.1111	±1.69148
Intra-Operative Data (Other Valvular Surgeries)		
By-Pass Time (mins)	161.9254	±64.08737
Cross-Clamp Time (mins)	128.9701	±51.88857
Intra-Operative Data (AVR+ARE)		
By-Pass Time (mins)	189.3333	±77.83155
Cross-Clamp Time (mins)	154.7778	±69.11906
Post-Operative Outcomes (Other Valvular Surgeries)		
Hospital Stay (days)	6.52	±2.003
ICU Stay (days)	1.99	±0.945
Post-Operative Outcomes (AVR+ARE)		
Hospital Stay (days)	5.4444	±1.74005
ICU Stay (days)	1.4444	±0.72648

Table 4 provided a comprehensive look into pre-operative lab reports and echocardiographic measurements, showing an average hemoglobin level of 12.4826 g/dL (SD = 2.22106) and creatinine levels at 0.8385 mg/dL (SD = 0.27113), indicating generally stable pre-operative renal function. Echocardiographically, the aortic annulus measured an average of 23.3224 mm (SD = 4.13659), with left ventricular dimensions and ejection fraction within expected ranges for a cohort undergoing valve replacement surgery. Notably, valve sizes differed between groups, with those undergoing AVR+ARE having smaller average valve sizes (20.1111 mm, SD = 1.69148) compared to other valvular surgeries, which could reflect the objective of ARE in accommodating larger prostheses.

Intra-operative data highlighted longer bypass and cross-clamp times for the AVR+ARE group compared to other valvular surgeries, suggesting increased procedural complexity. The post-operative outcomes showed a slightly shorter hospital and ICU stay for the AVR+ARE group, which may reflect the benefits of the procedure in terms of recovery.

Overall, the results from this study underscore the variability in clinical presentations and outcomes within the cohort, the impact of surgical strategies on procedural and recovery metrics, and the role of AVR and ARE in managing aortic valve disease. The nuanced understanding of these dynamics, as illuminated by the detailed statistical analyses, offers valuable insights into optimizing surgical interventions for aortic valve diseases.

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DISCUSSION

In the realm of symptomatic aortic valve stenosis, surgical aortic valve replacement (AVR) has long been established as the gold standard for treatment, aiming to alleviate pressure and volume overload on the left ventricle, relieve symptoms, and improve long-term survival prospects. At the Peshawar Institute of Cardiology, the study of 76 patients undergoing AVR, including those with the added complexity of aortic root enlargement (ARE), offers valuable insights into the effectiveness and outcomes of these procedures (22, 23).

The study's findings revealed an average patient age of 37.53 years and a mean BMI of 24.9125, suggesting that the baseline clinical characteristics of the cohort were within expected ranges for a population undergoing AVR. The demographic distribution showed a higher prevalence of male patients, who exhibited common symptoms such as palpitations and shortness of breath, reflective of the symptomatic burden of aortic valve disease. Etiologically, rheumatic heart disease emerged as the predominant cause, followed by degenerative and congenital origins, underscoring the varied etiological spectrum of aortic valve disease in this population. Notably, hypertension was the most frequent comorbidity, aligning with the established correlation between hypertension, aging, and the increased risk of cardiovascular events and mortality (23, 24).

Despite the prevalence of small aortic annulus conditions among the study population, the uptake of ARE procedures was limited, a trend that may be attributed to the surgical community's reservations stemming from concerns over technical difficulties, the risk of perioperative complications, and the debated significance of patient-prosthesis mismatch (PPM) (24). This hesitance persists despite evidence suggesting that ARE can mitigate the risk of PPM, a crucial consideration given the high frequency of small aortic annulus conditions encountered (25, 26).

The intraoperative data highlighted increased bypass and cross-clamp times associated with AVR+ARE procedures, reinforcing the perception of added complexity and potential risk. These findings align with existing literature, which has reported extended operative times and heightened reluctance among surgeons to adopt ARE techniques due to the anticipated perioperative and postoperative challenges (20, 25).

The study, while presenting a compelling case for the utility of ARE in preventing PPM, acknowledges limitations including its single-center design and modest sample size. The absence of long-term follow-up data further constrains the ability to assess the enduring outcomes and procedural morbidities associated with ARE. Despite these constraints, the research underscores the feasibility, safety, and positive short-term outcomes of ARE, marking a significant contribution to the surgical management of patients with aortic valve diseases (26, 27).

This investigation into the practices and outcomes of AVR and ARE at the Peshawar Institute of Cardiology underscores the necessity for broader acceptance and skill development in ARE techniques among cardiac surgeons. Future research endeavors should aim to expand upon this foundation with larger, multi-center studies incorporating long-term follow-up to fully ascertain the benefits, risks, and long-term impacts of ARE procedures (23, 28). The study's insights into the clinical and operative dimensions of AVR and ARE provide a valuable perspective for the cardiac surgical community, advocating for an enhanced understanding and application of these critical interventions in the treatment of aortic valve disease (7, 14, 17, 29).

CONCLUSION

The study conducted at the Peshawar Institute of Cardiology underscores the importance of aortic root enlargement (ARE) in conjunction with aortic valve replacement (AVR) for patients with small aortic annuli, demonstrating its feasibility and positive short-term outcomes. Despite the procedural complexity and extended operative times associated with ARE, the technique emerges as a valuable strategy to prevent patient-prosthesis mismatch (PPM), enhancing the post-operative quality of life for patients with severe aortic valve disease. These findings advocate for the broader adoption and skill development in ARE among cardiac surgeons, highlighting the need for further research with larger sample sizes and long-term follow-up to fully understand the implications and benefits of ARE in the management of aortic valve disease. This study contributes to the ongoing dialogue on optimizing surgical techniques for aortic valve disease, with potential implications for improving patient outcomes in cardiovascular care.

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